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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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572ND MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

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THURSDAY,

MAY 6, 2010

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ROCKVILLE, MARYLAND

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The Advisory Committee convened in Room T2B1 at the Nuclear Regulatory Commission, Two White Flint North, 11545 Rockville Pike, at 8:30 a.m., DR. SAID ABDEL-KHALIK, Chairman, presiding.

MEMBERS PRESENT:

SAID ABDEL-KHALIK, Chair
J. SAM ARMIJO, Vice Chair
SANJOY BANERJEE
DENNIS C. BLEY
CHARLES H. BROWN, JR.
MICHAEL CORRADINI
DANA A. POWERS
HAROLD B. RAY
MICHAEL T. RYAN

MEMBERS PRESENT (Continued):

WILLIAM J. SHACK

JOHN D. SIEBER

JOHN W. STETKAR

NRC COMMISSIONERS PRESENT:

CHAIRMAN GREGORY B. JACZKO

NRC STAFF PRESENT:

RAY LORSON

MERAJ RAHIMI

RON PARKHILL

DENNIS DAMON

ELIZABETH THOMPSON

GEOFF HORNSETH

DREW BARTO

LARRY CAMPBELL

SHER BAHADUR

MARTY STUTZKE

RICHARD LOBEL

DONNIE HARRISON

BOB DENNIG

AHSAN SALLMAN

ALSO PRESENT:

ALAN WOJCHOUSKI

STEVE HAMMER

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

(8:28 a.m.)

1) OPENING REMARKS BY THE ACRS CHAIRMAN

1.1) OPENING STATEMENT

CHAIR ABDEL-KHALIK: The meeting will now come to order. This is the first day of the 572nd meeting of the Advisory Committee on Reactor Safeguards. During today's meeting, the Committee will consider the following: revision 1C to NUREG-1536, standard review plan for spent fuel storage systems at a general license facility; two, preparation for a meeting with the Commission on June 9, 2010; three, meeting with the NRC Chairman; four, BWR Owners Group topical report NEDC-33347P, containment overpressure credit for net positive suction head and the staff's proposed guidance for the use of COP; five, preparation of ACRS reports.

A portion of the session on BWR Owners Group topical report NEDC-33347P and the staff's proposed guidance for the use of COP may be closed to protect information that is proprietary to General Electric Hitachi.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Mr. Christopher Brown is the designated 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 sessions. There will be several people from TVA and Westinghouse on the phone bridge line to listen to the discussions regarding containment overpressure. To preclude interruption of the meeting, the phone will be placed in a listen-in mode during the presentations and Committee discussions.

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 that they can be readily heard.

1.2) ITEMS OF CURRENT INTEREST

CHAIR ABDEL-KHALIK: I will begin with some items of current interest. Dr. John Lai, a reliability and risk analyst, will be joining the ACRS technical staff on Monday, May 10.

Prior to coming to ACRS, he was in the Office of New Reactors as a PRA reviewer for the ESPWR design certification and the combined license application for North Anna, Fermi, and South Texas projects. Prior to joining NRC in May 2006, he worked at Public Service Electric and Gas Company as a PRA engineer since 1995.

His other employment included working at PSE&G Nuclear as a nuclear fuel engineer. Southern Nuclear Company as a lead engineer, and Brookhaven National Laboratory as a research associate.

He has 30 years experience working in the nuclear area. He holds a Bachelor's degree in nuclear engineering from Xinghua University in Taiwan, a Master's degree in nuclear engineering from the University of Cincinnati, and a Ph.D. in mechanical engineering from Drexel University.

Ms. Elka Berrios will be joining the ACRS technical staff also on Monday, May 10. Ms. Berrios joined the NRC in February of 2006 as a reactor system engineer in the Office of Research. She graduated from the Nuclear Safety Professional Development Program in 2008.

Most recently she worked in the Office of New Reactors as a technical reviewer for various AP1000 combined license applications and a licensing project manager for the ESBWR design certification, the Grand Gulf early site permit, and the COLAs for North Anna and Fermi 3.

Ms. Berrios received her Bachelor's degree in mechanical engineering from the University of Puerto Rico and her Master's degree in mechanical engineering from Syracuse University.

Ms. Rachel Boyer has recently joined the ACRS PMDA as a program assistant. She will be responsible for all the travel coordination in support of the ACRS members.

Prior to joining ACRS, she was the program assistant for the Office of Nuclear Materials Safety and Safeguards, Division of Spent Fuel Storage and Transportation.

She has been with the agency since August 2004. She has had the opportunity to work in the EDO's office briefly, where she supported the Assistant for Operations. She also worked briefly in the Office of Nuclear Reactor Regulation and the Division of Policy and Rulemaking, where she had the opportunity to serve as their Information Management Assistant and assisted with the 2010 integrated regulatory review service mission.

Prior to joining NRC, Rachel was a State of Maryland employee for one and a half years at the Frederick County Health Department. Currently Rachel is a full-time student with the University of Phoenix pursuing an Associate's degree in business.

Welcome aboard to you all.

(Applause.)

CHAIR ABDEL-KHALIK: I have one additional announcement to make. After 38 and a half years of working at the NRC, Ms. Michele Kelton will be retiring in early June.

PARTICIPANT: She is only 22.

(Laughter.)

CHAIR ABDEL-KHALIK: Ms. Kelton started with the Atomic Energy Commission in August of 1971 as a secretary in the Division of Reactor Licensing, now the Office of Nuclear Reactor Regulation.

In May of 1975, Ms. Kelton joined the ACRS as secretary to a senior staff engineer. Ms. Kelton has remained in ACRS since 1975, holding positions of increasing responsibility, including secretary to the Deputy Director of ACRS, technical secretary to the ACRS and ACNW, and at the current position as management analyst. Her dedication, hard work, professionalism, attention to details, and exceptional work ethics are very much appreciated.

We thank her so much and wish her the best in her future endeavors.

(Applause.)

CHAIR ABDEL-KHALIK: We will now proceed to the first item on the agenda, "Revision 1C to NUREG-1536." Dr. Ryan will lead us through that topic.

MEMBER RYAN: Thank you, Mr. Chairman.

2) REVISION 1C TO NUREG-1536

2.1) REMARKS BY THE SUBCOMMITTEE CHAIRMAN

MEMBER RYAN: The purpose of today's meeting is to receive a briefing on updates made to the staff's standard review plan for spent fuel dry storage systems. The Committee will hear presentations by and hold discussions with representatives of the staff from NMSS Division of Spent Fuel Storage and Transportation.

The subcommittee meeting was held on February 17th, in which the staff presented background information, regulatory criteria relating to the design of the storage cask and typical storage operations. A new risk-informed priority scheme was also discussed, which raised a number of questions from the subcommittee.

Another subcommittee was held on April 21st, 2010, in which the staff continued the briefing on its updates on the standard review plan of dry storage casks. I am sure we will cover some of that same material and particular points that developed in discussion with the Subcommittee.

So, without further ado, I will turn it over to Ray. Please?

MR. LORSON: Thank you, Dr. Ryan. Thank you, Chairman. And thank you, members of the Committee.

2.2) BRIEFING BY AND DISCUSSIONS WITH REPRESENTATIVES OF THE NRC STAFF

MR. LORSON: I am Ray Lorson. Deputy Director for Technical Review in the Division of Spent Fuel Storage and Transportation in NMSS.

I just want to thank everybody for the opportunity to come here today and to talk about a lot of the hard work we have been doing in updating our review guidance for the staff. Basically we use this guidance for licensing of dry storage systems for spent fuel.

As Dr. Ryan had mentioned, we have previously briefed the Subcommittee for Radiation Protection twice on this topic and have received a number of great comments that we have used to make the document better and even stronger.

With that, I will turn the presentation over to Meraj Rahimi, who is our Branch Chief in SFST responsible for the implementation of the SRP.

MR. RAHIMI: Thank you, Ray. Thank you, Dr. Ryan and Mr. Chairman. I am Meraj Rahimi. I am the Acting Branch Chief for the and Containment Branch, the Division of Spent Fuel Storage and Transportation.

The purpose of the briefing today is to brief the members on the update to the standard review plan at the fuel dry storage system at a general license facility and obtain and welcome any comments that there will be proof. And we had an excellent two previous meetings, which really resulted from insightful comments from the members that made, as Ray mentioned, the document better and stronger.

NUREG-1536 actually has been in use by the staff as a guidance to the staff since January of 1997. So it's been used by the staff more than 13 years. And it was about time to update the documents with numerous interim staff guidance that had been issued during that period.

And so we took that initiative. And we updated. And we briefed the subcommittee on February 17th and April 21st on the results of our activities.

We gave a background at those two meetings about division of spent fuel storage and transportation. And we also sort of tried to give a quick background about the typical dry storage cask operation of reactors. And we presented a regulatory basis and the design basis for each of the items.

Can you go to the previous slide? Okay. And what we presented in those two meetings, it was the overall project approach. And then as the result of the good comments from the subcommittee, the main focus of the revision was the prioritization method we presented, how we prioritized each section, the technical review portion of the design in terms of the priority: important to safety.

And we went over in those two meetings about the key revision in each of the sections. And also we presented the significant comments, some of the significant comments, we had received from the members of the public. Mainly those comments were from the NEI and from one of the cask vendors.

Next slide, please. As a result of those two meetings that we had with the subcommittee, we went back. Previously we had used the term "risk-informed." And the subcommittee rightfully pointed out what we were looking at is not really a risk. You know, there are no probability consequence numbers. And it is more appropriate to call it prioritization, which we did that. So we went back to the document. And we revised the document and used the term "prioritization."

There were other issues identified by the committee. They identified polymeric neutron shielding materials being important to safety. Previously it had been sort of ranked as low-priority. So we changed that.

And also we went back, and we reevaluated some of the prioritization methods criteria. And we reevaluated the low or very low ratings on specifically question 2. Ron will go over those questions, what we mean by question 2.

And as a result of the last meeting that we had, we did change. We had used the term "catastrophic consequence." Indeed, that was not appropriate, as the committee pointed out. So we changed that to "significant," as opposed to "catastrophic."

And also there was a very good discussion at the last meeting on the burnup verification measurement because in this version of the SRP, what we put in as a guidance for the staff, it was if an applicant comes in, they ask for burnup credit.

So far we haven't had any cask vendors to come in designing casks, the criticality safety based on burnup credit. They've been designing casks based on boron credit in the pool for the PWR.

So we provided this guidance in the SRP for the future. So because we are forward-looking in case -- especially with the anticipation of dual-purpose casks, multi-purpose casks, you know, some vendors, they might decide from the very beginning they want to have a design that is also certifiable for transport.

MEMBER RYAN: Dr. Rahimi, I might say that is probably the one point where I think we will need to reserve some time because I think the full Committee will want to hear some of the details of that discussion.

MR. RAHIMI: Definitely, sure. We will be more than happy to. And I think the committee made really insightful comments in terms of -- so hopefully this time we will try to explain our position more clearly.

MEMBER RYAN: Have you revised your position based on the subcommittee's discussion?

MR. RAHIMI: We did some revision based on your comments. We went back to the SRP. We provided some clarification.

MEMBER RYAN: Particularly on the burnup question?

MR. RAHIMI: Particularly specific --

MEMBER RYAN: Okay. Great. So that will be a good focal point for us.

MR. RAHIMI: Yes.

MEMBER RYAN: Thank you.

MR. RAHIMI: We will be more than happy to go over those. And so today's presentation, Ron will lead us off. He will go over quickly the overview of the project and the public comments that we received.

Dr. Damon also he helped us tremendously to review the methodology, prioritization methodology. And Liz Thompson will go over the radiation protection.

Also, the last time we were here, Bob Einziger gave a presentation on the spent fuel oxidation, is not here today, but Ron will go over some of the slides that you were interested. We didn't have it, I think, some pictures about the oxidation. So we will go over that. And at the end, I will cover the burnup credit measurements.

And, with that, Ron?

MR. PARKHILL: Thank you. My name is Ron Parkhill from the Office of Spent Fuel Storage and

Transportation.

This document that we have before you has been in use for 13 years. We have said that before, and we will probably say it again before we are done.

We started this update project four years ago. And we have incorporated the staff guidance that we had in place, which was a formal process of ISGs that are issued and approved by our office director. And then we also made other changes that we deemed necessary, like updating it per the regulations that are specific to a general license facility.

We prioritized the review procedure section of each SRP chapter to help the staff better utilize their time. We added a brand new materials chapter, not that the material in the materials chapter was new. We just consolidated it so that a materials reviewer would have a format specific to his discipline and provide some uniformity. Also, this standard review plan enhances our knowledge transfer.

We sent it out for public comments. We got a bunch from industry, 192 from NEI. One of our vendors, NAC, submitted 30. Those comments were basically duplicative of the NEI comments.

Each of those comments, each and every one of them, is listed in appendix D to the standard review plan as well as our disposition. And it is important to note that we agreed with the majority of the comments, over 60 percent. And this definitely resulted in a better product.

I would now like to talk about the prioritization methodology. The method that we developed, Dennis Damon, sitting to my right, was instrumental along with our contractor in coming up with this methodology to help us prioritize our review procedures section of the standard review plan.

So what do we mean by "prioritization"? It means that when we go to the review procedures section, we are trying to identify each and every effort or activity identified there for the staff to do to qualify it as either high, medium, and low, meaning high he spends, he or she spends, more time on it.

Medium is about the same level of effort. And low means they spend less time on it. We look at all items that are classified as low. We just don't spend as much time looking at it.

The typical standard review plan chapter structure is identified there with a review objective, areas of review, regulatory requirements, acceptance criteria, and review procedures, and evaluation findings.

Again, for emphasis, the only thing we have prioritized was the staff's actions under the review procedures section.

VICE CHAIR ARMIJO: Ron, before you leave that, I think there was a key point that at least I felt was key in that a review that is categorized high also receives independent confirmatory analyses.

MR. PARKHILL: Yes. We have --

VICE CHAIR ARMIJO: Like the staff --

MR. PARKHILL: -- staff definitions for each one of those terms that's in the methodology that we employed. I'm glad you mentioned that because the methodology we employed is documented in the attachment to the standard review plan in detail. And it describes in-depth what we mean: high, medium, and low. And also I think in the introduction to the standard review plan, we also define those terms.

But you are absolutely right. High means additional emphasis on confirmatory analysis on the part of the staff.

The method -- I know this diagram seems a little bit tedious -- is not as bad as the diagram looks. We asked three questions for each item in the review procedures section that we want to prioritize.

The three questions are identified there as one, two, and three. The first question that we asked is the likelihood that the requirement will not be met by the applicant.

Based on a review of three experienced staff -- again, let me back up a minute. Each one of these questions is posed to a members of our staff, three of them, that are all experienced that would answer that question. And then in a consensus, they would come up with the final evaluation or rating there. So it's not a single person that's using their view. We tried as best as we could to normalize it.

So the first question that we asked for an time that we want to prioritize is likely that the requirement will not be met by the applicant. And based on our experience, we identify it as a zero to four of improbable all the way to likely to occur.

We also give a qualitative as well as a quantitative measurement there. Again, it's the judgment of the people, experienced staff, making that determination.

The second question that we ask is the likelihood that the staff will find a discrepancy. Surprisingly, we rate ourselves very good since we're following the standard review plan. And so we don't give ourselves bad grades in that. We generally think we are going to do a good review.

With that said, there were a few items that we identified, the staff identified, as low or very low for the reason that we didn't consider the important based on experience or we just didn't look at them.

I think basically we made a predetermined decision not to look at them for a compelling reason. Based on the ACRS' comments, we have changed the process there.

So for every item that we identified by that original panel of being either low or very low, at the end of the rating process, we go back and visit that item to make sure that we didn't make a mistake.

And as a result of tweaking the process, we had six items in that category that we rated low, as very low. And the risk aspect of those items, four of those items, was also low. So we weren't too concerned if the risk was low. But where the risk was medium or high, we went back and reviewed the rating.

One of those ratings, we still left it as low, but on another rating, we upped it. So the message for the Committee here is that we just don't go back and leave an item that's where the staff feels that they want to identify it without more additional review. And we will change the prioritization process of attachment B to reflect that.

MEMBER BLEY: Ron, can I push you on that one? You explained this a while back. I was pretty comfortable. But the way you just said it still leaves a little gap for me.

The one I worry about may never happen, probably won't, but an item is very high for the applicant will miss it. So that's a four. It's high for risk consequence. So four and three is seven. And you guys have the zero. At least that gets it to a medium now, instead of a low.

What I was worried is something not being covered because you guys will end up with a low --

MR. PARKHILL: I don't want to leave you with the impression that we don't cover anything. Even a low we look at. And medium isn't bad news.

So a medium is our normal review, but our process is in your scenario where you had us very low on identifying it, we would go back and raise that if the risk was medium or high, that item would at least be raised up to a medium level.

MEMBER BLEY: That's what I wanted to hear.

MR. PARKHILL: Something with a high risk is not a low. So, going back to the process, we take those three numerical values, add them together, and get what we call a risk score. That has an associated high, medium, and low based on the addition of the three previous questions and --

MR. RAHIMI: Ron, there is a question.

MR. PARKHILL: Oh, yes.

MR. RAHIMI: John?

MEMBER SIEBER: Could I interpret the item 2, the likelihood that the staff review or find the discrepancy? If I would score that as zero or that would mean that I don't think that the staff will find it.

And by virtue of scoring it as zero, I won't look as hard either. Isn't that sort of the reverse of what you want?

MR. PARKHILL: Well, I think we are looking at everything, but one of your premises is the reason for scoring it low is usually based on experience in that item as it not being important based on our previous reviews.

MEMBER SIEBER: But that is not what it says. It says specifically the likelihood that the staff review will find the discrepancy. And if you say, "I don't think I am going to find it. So I am not going to try" --

MR. LORSON: Yes. I think, if I can answer for Ron, I think that that could be one way you could interpret it. I think the explanation that I understand from the folks who are involved in the process is that we looked at it from the perspective of we typically don't find problems in this area. We think we're doing an adequate review, but we just haven't seen these as problematic for us based on our experience.

Having said that, I think what Ron mentioned is because we heard the comments at the subcommittee briefings about potential ways that that question could be answered that could give you to a lower-level review than what may be warranted based on the significant events.

So we actually went back, re-looked at all of the cases where we answered low or very low and made another assessment to see whether or not we end up with the fine correct rating.

MEMBER SIEBER: But if you were to conclude that I haven't found discrepancies or errors like this in the past, I wouldn't charge it to item 2. I would charge it to item 1, which says "unlikely to occur." In other words, you know, to me the logic is just a little fuzzy there.

MR. PARKHILL: The example that I was referring -- I'll give you an example to what I was referring to -- is in the thermal analysis under accident conditions for the fire, we have done enough of those analyses to know that the fire under thermal conditions doesn't impact the casks. There is just not enough fuel on site to effect the thermal inertia of it. So we said, why continue doing these reviews?

So we have rated that as a low based on experience of prior knowledge.

MEMBER SIEBER: Okay. That --

MR. PARKHILL: And we applied it in question 2. It's not to say that all question 2's were handled that way.

MEMBER SIEBER: Yes.

MR. PARKHILL: But that is what comes to mind.

MEMBER SIEBER: Well, I would have applied it to question 1. In other words --

MR. PARKHILL: That is the applicant. Question 1 is the applicant.

MEMBER SIEBER: Right.

MR. PARKHILL: That's action by the

applicant.

MR. LORSON: I think you have a --

MEMBER SIEBER: The applicant if he does nothing and fire damage won't hurt, then that's where I would --

MR. PARKHILL: If the applicant did nothing, that would be question 1, but if the staff recognized the fact that they have always submitted an adequate analysis there and that analysis had never really, let's say, had a determining impact on the results, you know, so we choose to rate question 2 low, give them credit for adequately doing the analysis.

MEMBER SIEBER: Maybe it's the way it's worded that's disturbing.

MR. LORSON: I agree. The way it is worded, maybe you could have a misinterpretation, you know.

MEMBER SIEBER: Well, just so the staff doesn't misinterpret it --

MR. LORSON: No. And that's why we went back and we re-looked at all of the specific review chapters where we rated it as either low or very low, just to make sure that we didn't leave something unturned that we should have provided a higher level

--

MEMBER RYAN: Have you modified the text in any way to explain this or put some footnotes in the table to do that? Have you done that?

MR. PARKHILL: It will be done. We have a control copy. We're making a commitment to do it.

MEMBER RYAN: Okay. Great. All right.

MR. PARKHILL: All those things that --

MEMBER RYAN: I was just curious. I was going to say if you had done it, we might hear about it. But if you can clarify --

MR. PARKHILL: Right.

MEMBER RYAN: -- so that that confusion is avoided, I think that would be helpful.

MR. LORSON: We will do that. I think there is one other piece of information. I would just like to make sure that it is clear that these are review guidance procedures. Okay? We expect the staff to use it as guidance.

But in the case where we have a unique design or design comes in where they are very close to very little margin, we would expect in those cases that the staff would use it as a guidance but then look at the uniqueness of the application or the proximity to a margin to adjust their view to be a little more robust.

So, you know, it's kind of a starting point for us, but it's by no means concrete.

MEMBER SIEBER: Okay.

MR. LORSON: We do have flexibility.

MEMBER RYAN: Thank you.

MEMBER POWERS: Do I understand correctly that item 3 is a conditional probability or is it a consequence?

MR. DAMON: It's not. It's what it says. It's the product. It's an increase. It's the impact on the product of probabilities times consequences that would occur because of the deficiency. So it could be either. Whatever the deficiency is could affect consequences. It could affect likelihood. And so it's the combination of the two. It's all weighted.

Of course, this wasn't done quantitatively. So the logic I am stating is strictly in the minds of the beholder. But quantitative --

MEMBER POWERS: It's a little confusing to me because it doesn't appear to be a product.

MR. DAMON: Well, I'm mentioning both consequences and likelihood.

MEMBER POWERS: Yes, but it's an and/or

relationship there. And it's a question. It says, "the risk if the requirement is not met." So that would say it's conditional risk.

MR. DAMON: Yes. You can do it either way. You can do the change, you know, like you did in the ROP, the change in risk, or you can do the absolute level of risk that you reach because of the deficiency. Either one has a certain value to it.

I personally like the latter, absolute level that you reach, because it can be related to an individual risk metric that you want to avoid. But we're not doing this quantitatively. I mean, they've got numbers here to sort of focus the adjustment of --

MEMBER POWERS: Yes. It gives you a -- and I don't do it. I mean, actually, I find the numbers more useful than the statements. The statements are just confusing me to death.

It seems to me that what you want is okay. It's greater than 10-3 per year or you can expose somebody to 25 rem if something bad happens here. That I understand.

The statement is just very confusing to me because it seems like it's not what you want. What you want is exactly what you have said over there on the side, is it's not a conditional statement.

I don't care what they did with the requirement. Does this thing result in 10-3 probability of occurring or exposing somebody to 25 rem, irrespective of what anybody did to it?

MR. DAMON: Well, no. I mean, that's what was intended by the statement. In other words, the logic here would be it's not sort of described here.

The first step really would be to postulate given this area of review that we are reviewing, this step in the review procedure, what could the licensee do? It's the same risk triplet. What could the licensee do wrong?

So you would make a list. And then you say, what is the likelihood they do one of these mistakes? So that is the first step. What is the likelihood that they make a mistake?

And then the third step is, well, if they made that mistake -- so it is conditional -- if they made that mistake, what would be the resultant, you know, consequences and likelihoods for accidents? And if you were doing quantitative --

MEMBER POWERS: You are not helping. You are just confusing me to death. It's either conditional or it's not.

MR. DAMON: It's supposed to be

conditional. It's not like --

MEMBER POWERS: You just told me it wasn't conditional first and now it is conditional. It is transparently conditional.

MR. DAMON: Given that they have made a mistake of some kind, that is what you are looking for. When you do a license review, that is the purpose of the review, is to determine the licensee, in fact, has designed and then analyzed the thing properly.

And so there is some level of risk that is based on, yes, the thing has been designed correctly, but the reviewer is looking, okay. What if they didn't do it correctly? And so that is the logic of the thing.

MEMBER POWERS: Then it is a probability. It is not a risk metric. You are just really confusing. If it is not a risk --

MR. DAMON: Well, the probability they did it wrong is number one. And then you are going to multiply it by -- I mean, if you did this quantitatively, then you would be multiplying by a change in risk or in absolute risk level that would result given that they made that particular mistake.

MEMBER POWERS: So I have a .025 rem per

year is what you are telling me. I mean, the numbers don't match.

MR. DAMON: Well, let me give you --

VICE CHAIR ARMIJO: Dennis, I think the problem is the use of the word "risk." If we just substitute "likelihood" and "consequences" if risk is not made, instead of the word "risk," where we are trying to force-fit it into a more precise -- what you have on the right-hand side, it's easy to understand on that chart. But when you put the word "risk," it implies something that is not being done.

MR. LORSON: So if the left side said, "likelihood" and --

VICE CHAIR ARMIJO: And "consequences."

MR. LORSON: -- and "consequences if" --

VICE CHAIR ARMIJO: You should put that on the right-hand.

MR. LORSON: No. I think that would be a good approach.

PARTICIPANT: For question 3.

MR. LORSON: Yes. Yes. Okay. Any other questions on the slide?

MEMBER RYAN: Press on.

MR. PARKHILL: Once we get risk score soon to be renamed something else, we make a determination on defense-in-depth. And the defense-in-depth is scored the same as the risk with a high, medium, or low. And then we make a determination as to which one we view to be more important: the risk component. Forgive me if I keep using that, but we'll change it.

For the defense-in-depth, just some information on how we went about this process. Not everything that we reviewed and the review procedures or prioritized in the review procedures had a defense-in-depth determination.

Roughly 1 out of 6 or 25 out of 143 had a defense-in-depth determination. And 8 of those 25 actually used defense-in-depth to raise the score. We never used defense-in-depth to lower the score. It was always used to raise it.

MEMBER POWERS: Don't tell Apostolakis that.

(Laughter.)

MR. PARKHILL: There are those who believe that the ends justify the means. The results that we got here show the 143 items that we have in our standard review plan review procedures sections.

All the chapters are listed there. And of those, 44 are high, 65 are medium. And medium means it's a normal staff review. Low basically means we still look at it. And in general, we look at it to see that it's addressed and makes sense, that it's not in as much detail as we would normally do.

And we had changed based on the subcommittee's comments and specifically question 2 that we talked about earlier under materials. One of the low items became a medium on that tweaking of the process.

And if there are no other questions, we will go along to radiation protection, Liz Thompson. And she is sitting on the side. She is now sitting up front. Please?

MS. THOMPSON: I am Elizabeth Thompson. I am a senior health physicist in SFST. I am going to talk to you a little bit today about radiation protection as it relates to the licensing of dry cask storage systems.

In this revision of the standard review plan, we incorporated the applicable interim staff guidance into the radiation protection chapter. So we did not greatly change the way that we do our radiation protection reviews.

MEMBER BROWN: Could I ask you one question? In section 6 is where I saw a bunch of the acceptance criteria for boundaries and things like that. Were any of the acceptance criteria changed as a result of this update or was it just --

MR. PARKHILL: Prioritization?

MEMBER BROWN: -- prioritization process and procedure-type?

MS. THOMPSON: Process procedure clarification.

MEMBER BROWN: Okay.

MS. THOMPSON: Okay? Technically chapter 6 is shielding.

MEMBER BROWN: That's what I --

MS. THOMPSON: Shielding and radiation protection are very closely related and frequently have the same reviewer unless there are specific concerns about a particularly design where we want to have two people really concentrating on it.

In our previous briefings to the subcommittee, several questions came up about doses involved in cask-loading campaigns. So we got some information to present to this group, and in looking at some inspection reports found that typically doses for a single-cask load ranged between 300 and 500 person-millirem for the entire crew. These range from the point where you put the canister into the pool to when you have loaded it into the overpack on the storage pad. Okay?

MEMBER RYAN: Liz, do you have a rough number of how many people are in that crew?

MS. THOMPSON: Funny you should ask that, Mike. For at least one specific example I found, it involved 515 millirem spread across a crew of 57 people.

One hundred and ninety millirem of that went to the ten members of the loading, rigging, and crane operations crew. Let's see. I think 151 millirem of that went to the 13 radiation protection technicians.

The highest average for the group was to the welders. That was a crew of 4, who received 23 millirem each on average. And the highest individual was one of the supervisors on the loading, rigging, and crane operations crew, who received 32 millirem.

So, as you can see, while in general there are not high individual doses associated with these activities -- now, that is not to say that they never exceed these values. This is just for one operation we found where we had more information than we have for a lot of --

MEMBER RYAN: This is a loading of one cask or many casks?

MS. THOMPSON: One cask.

MEMBER RYAN: One cask.

MS. THOMPSON: Like I say, typically for a single-cask load, the total dose to the crew ranges from 300 to 500 millirem. I saw instances where it was as low as like 32 millirem or in a couple of instances over 1 rem to the crew.

MEMBER BROWN: How many casks would be in a loading operation, say 32 millirem for the supervisor or one cask? And if you did ten of those and you were starting to talk about --

MS. THOMPSON: Now you lead me into my little trends talk and campaigns. On a per-campaign basis, there is not a lot of comparison you can do because a campaign can be loading anything from one cask to loading ten. It just depends on what it is for a specific utility at a specific point in time that they need to move from their fuel pool into dry storage. So I couldn't find any meaningful way to present information there.

To talk about your question a little bit, though, we do see some general trends, for example. When a utility loads more than one cask during a campaign, they're typically using the same loading crew.

And this is generally a mixture of utility personnel and contractor personnel. And as that crew gains experience with the specific setup at the utility with the equipment they have brought in to do the operation, the dose typically goes down. It's not a monotonically decreasing function, but in general, the trend is for the dose to the crew to go down as they gain experience with an operation.

MEMBER BROWN: It is a learning curve, in other words?

MS. THOMPSON: Yes.

MEMBER BROWN: Thank you.

MS. THOMPSON: Then the other thing we noticed, though, is that as the heat load increases, that it can be roughly correlated with the activity. It is not a perfect correlation. But in general, as the heat load increases, the dose to the crew has the potential for going up because the dose rate outside the transfer cask and canister tend to be higher.

Looking over, I looked over a fair amount of data for this and did not see very many instances where we get far out of the range. Like I say, the highest I saw was like 1.1 rem to the entire crew for a cask load. I saw a few that were in the 500 to 900 range. The vast majority were between 300 and 500.

Again, that's millirem to the entire crew for the entire operation.

VICE CHAIR ARMIJO: Is there a difference between the welded canisters and the mechanically sealed that leads to differences in doses?

MS. THOMPSON: I don't have the level of detailed information that I would need to make that statement. Given the range of doses that I saw for the entire loads, I wouldn't expect that there is a large difference.

Do we have any other -- oh, one other question that came up that I said that I would find something out about, there were questions about the dose at the controlled area boundary, which is a minimum of 100 meters from the ISFSI and in talking to some of our region inspectors found out that typically the dose at the controlled area boundary is not distinguishable from background.

MEMBER SIEBER: Right.

MS. THOMPSON: Any other questions?

(No response.)

MEMBER RYAN: Thanks so much, Liz.

MS. THOMPSON: You're welcome.

MEMBER RYAN: I might make a note here that Liz is retiring at the end of the month. And she has been a long-serving health physicist here at the NRC. And you wish her well in her retirement endeavors. Thank you for all your hard work.

MS. THOMPSON: Thank you, Mike.

VICE CHAIR ARMIJO: Thanks, Liz.

MR. PARKHILL: At the last meeting, Dr. Robert Einziger gave you a presentation on fuel oxidation. He is at the dry cask storage forum today, I think making another presentation, not necessarily on this, but I believe it's on cask longevity.

We are concerned about fuel oxidation, which is oxygen coming into contact with a cladding that has a breach in it. So if air gets in contact with the uranium oxide, it will turn into U3O8. And the problem with that is it gets a 30 percent expansion. And we have compromised the cladding integrity there. It also produces an oxide, which is powder-like and is a potential release issue.

The important thing to remember here is we don't have that problem because all of our casks that we have loaded or been licensed and loaded are stored in an inert gas. But it is an issue we have been aware of since the very concept of dry cask storage. And our guidance has always been from the late '80s to stored in an inert gas.

Here are some pictures that Bob wanted to present last time. And I guess we didn't have them on the computer. So he couldn't do that.

For time and temperature, you can see that the cladding will split if you put a -- I think it has a 16th to an 18th of an inch defect that is put into the cladding and then is surrounded by air and exposed for the duration and temperature that you see there and has resulted in obviously proximal splits of various lengths. And, really, I am having a little trouble seeing the one on the left.

We have a little better picture in the following. The reference is from a paper by Bob Einziger in 1991 there.

MEMBER POWERS: When you say "we store in inert gas," the question that I want to ask is if I take this big assembly and put it in inert gas and I measure the oxygen potential in that inert gas, I will get a number because there will be a little water vapor absorbed onto surfaces. There will be a little oxygen entrained in things, stuff like that. Does that cause you any problem?

MR. PARKHILL: Well, the guidance in PNNL recommended a purity level of the helium that we --

MEMBER POWERS: The helium. The helium

purity level I k now.

MR. PARKHILL: Yes.

MEMBER POWERS: Okay? It is all the -- I mean, typically if I put up a vacuum system and put a structure into it, it takes me days to get my oxygen potential down. And I do lots of elaborate things. I spark it with a Tesla coil and all kinds of things to get stuff off the surface.

Here you are not doing all of that elaborate stuff. And I am just wondering, is the residual water or whatnot going to cause you a problem?

MR. PARKHILL: It's at the bottom of a cask. So it's not in contact with a fuel. You have helium mainly in contact with any cladding defect.

MEMBER POWERS: But anything I have got is going to be in that helium gas. I mean, if I've got water in the bottom or I've got oxygen absorbed on things, it will be in the gas eventually.

VICE CHAIR ARMIJO: You have got radiolysis in the water, a lot of stuff going on. But the quantities are really small. You have a rather depending on the system drying process you have to train.

MR. PARKHILL: It doesn't have to be

absolutely dry.

VICE CHAIR ARMIJO: Yes, I understand that.

MR. PARKHILL: We all know that. So there is water in there. And I guess the experiments and data that we've taken to date haven't shown a problem with that. It's a realization that yes, there is some residual water remaining in there. I really can't speak to the quantity, but it's recognized that a little bit is there.

MR. LORSON: But I guess the question is, that small amount of oxygen or moisture that remains in the cask, could that present a potential problem, such as the fuel oxidation? In other words, does it rise to the concentration level that would be needed to cause this type of effect?

And I guess that's a question we would probably have to take back and think about a little bit.

MEMBER POWERS: I am not asking you to solve the question. I am asking you --

MR. HORNSETH: I think I can answer the question right now. Geoff Hornseth, senior materials engineer, Spent Fuel.

We have had the opportunity to examine

fuel that has been stored for a number of years in dry storage casks. They were opened for a variety of reasons. One of them was the INEL study that we did some years ago. The others were at least three or four casks at one facility that had to be reopened for totally unrelated reasons.

In every single case, the fuel looked pristine. It looked precisely the way it did the way it went into the canister. And this was after in some cases up to 15 or almost 20 years of dry cask storage.

MEMBER POWERS: What was that? That doesn't answer this question.

MR. LORSON: Right. I think that provides a data point --

MEMBER POWERS: That's a data point.

MR. LORSON: -- that we haven't experienced the problem to date that we know of and our examinations have not identified a problem, but I think the question that Dr. Ray [sic.] is mentioning is in a limiting condition, if you have your limiting condition for what you allow in moisture content and potentially oxygen content that you are not monitoring, could that result in a concentration within the cask such that you exceed some minimum threshold value that is needed to cause fuel oxidation?

MEMBER POWERS: Yes, with the addition that you have to have a defect in the clad.

MR. LORSON: With a defect in the clad.

MEMBER POWERS: Yes, right.

MR. LORSON: I think that that question is a little more theoretical way off the --

MEMBER POWERS: Yes. I mean, I think it's a back-of-the-envelope calculation.

MR. LORSON: Yes.

MEMBER POWERS: But it's one I have not --

MR. LORSON: I think we can answer it. You know, I think Bob Einziger if he were here would be able to provide you --

MEMBER POWERS: Probably still off the top of the head and will confuse the hell out of me, but --

MR. LORSON: Yes. The folks we have here today, I don't think we can answer that question.

MEMBER POWERS: Yes.

MEMBER SIEBER: But if the fuel fails in this manner, it doesn't result in an immediate threat to the environment or anything else as long as the package itself remains intact.

MR. LORSON: Correct.

MEMBER SIEBER: On the other hand, when you finally have to do something with it, it's going to be --

VICE CHAIR ARMIJO: That's a mess.

MR. LORSON: And, again, we are talking very long-term dry storage safety. We want the fuel to not only cause a problem while sitting on the pad, but we want to have confidence we can transport it and that it could be readily accepted by wherever it goes without the need for revacuuming.

So we will take that question back. And we can provide an answer.

MEMBER POWERS: I'm sure it's just a back-of-the-envelope calculation.

MR. LORSON: I'll move on.

MEMBER POWERS: I am certainly not looking for anything more than that.

MR. LORSON: I understand.

MR. PARKHILL: This is just another picture from a different reference of the effect of fuel oxidation, a little better picture. It shows the initial defect and how the crack grew from that once air was exposed to it. Not surprisingly, it grows from the center outward.

And this resulted -- well, it's not shown on there, but this is for 250 days roughly at 229 degrees C, so a longer time, lower temperature, still resulted in a significant crack.

MEMBER RYAN: Onto burnup credit.

MR. PARKHILL: Excuse me?

MEMBER RYAN: Onto burnup credit, right?

MR. PARKHILL: Yes. We void this because it put it in an inert gas.

MEMBER SIEBER: Now, you backfill the canister with the inert gas. Once you get the gas in there, you just shut the valve, right?

MR. LORSON: Well, right. We require that the gas be leak-tested before it is loaded.

MEMBER SIEBER: Yes.

MR. LORSON: Okay? And after the system is backfilled with the helium and we shut the valves and the valves themselves have caps that are welded on and then those caps are leak-checked also to ensure that they are not leaking --

MEMBER SIEBER: Yes. But once you do that, that's it for being able to measure the gas pressure inside the canister.

MR. LORSON: For the welded systems, that is correct. There is no at this time additional requirement to go back in and --

MEMBER SIEBER: So if you had a leak, you would not know it. Of course, now -- and the gas is under pressure, right?

MR. LORSON: It varies from vendor to vendor, but they can use up to -- I've seen designs up to seven atmospheres of helium pressure inserted as a back pressure.

MEMBER SIEBER: So if your analysis relies on that pressure and you do have a leak someplace, over a long period of time, a year or two, it would leak off. Then you may end up with this condition and not know it.

MR. LORSON: Well, I think what you would get down to --

VICE CHAIR ARMIJO: I had exactly the same questions. And they sent me their designs. And I finally understood your designs. There are two welds between --

MEMBER SIEBER: Right.

VICE CHAIR ARMIJO: -- the high-pressure helium and the atmosphere in the welded canisters. I believe that is the case. So you have got a defense-in-depth from the ceiling.

MEMBER SIEBER: On the welding.

VICE CHAIR ARMIJO: Right.

MR. LORSON: But I think the point is if there was a small leak, the helium could escape. So I would lose my overpressure as a function of time. I would get down to a point where I had one atmosphere of pressure in the helium. And I think at that point, then, my leak rate would significantly drop.

VICE CHAIR ARMIJO: Well, no, Ray. Barometric pressure will change, right? So the helium would come out. Now the barometric changes in the other direction. And stuff could come back in. And over time --

MEMBER SIEBER: You're going to have some --

MR. LORSON: Right, over time. And, of course, remember, when we talk over time, the spent fuel is continuing to decay down as the heat load goes down, which is another primer in this oxidation question.

But I think that is another back-of-the-envelope calculation. If you had nominal barometric changes, how long would it take before you got yourself into a percentage of oxygen in the atmosphere that it could cause a problem like this?

Now, we have done some calculations for postulated leak rates of -- and then they were 10-3 cc per atmosphere per second. And using that postulated leak rate and taking credit for the reduction in the driving head as a result of the continued loss of the overpressure of the helium, we have seen it takes up to 430 years before we actually get down to atmospheric pressure before the barometric changes would take place that we are referring to.

And so we can go back and do another back-of-the-envelope calculation, I think, to analyze the --

VICE CHAIR ARMIJO: I think all of those calculations are right if the leak rate stays at 10-3 --

MR. LORSON: True.

VICE CHAIR ARMIJO: -- and it doesn't grow. And so the advantage of the bolted stuff is you do have monitoring capability that you don't apply on the welding. But with double welding, I was getting kind of hot and bothered about that but finally decided it was pretty practical.

MR. PARKHILL: And that 10-3 assumption of a leak rate is like 4 orders of magnitude more --

VICE CHAIR ARMIJO: I understand.

MR. PARKHILL: -- more than what it's leak-tested for. So it's a pretty drastic assumption there.

MEMBER RYAN: I think we've got this one covered. Can we move on?

MEMBER SIEBER: Yes.

MEMBER RYAN: Time is short.

MR. LORSON: Okay.

MEMBER SIEBER: Well, it's consistent with the likelihood that a permanent repository will --

(Laughter.)

MR. LORSON: In 434 years hopefully the confidence will be somewhere.

MEMBER POWERS: You are more confident than they are.

MR. RAHIMI: Okay. As I said earlier, in this revision of the SRP, what we have included as part of the guidance to the staff is about burnup credit, meaning that if an applicant comes in, they have designed their criticality safety systems of the storage casks based on burnup credit.

We provided guidance. And in that guidance, it also talks about burnup verification measurement. And one of the I guess significant comments that we received from NEI was saying delete performing measurements to confirm assembly burnup values.

That was a comment received from NEI. The industry in general --

MEMBER POWERS: When you talk about a confirmatory measurement, what are you really looking for there?

MR. RAHIMI: Right. The reason I think -- we are going to try to explain this better in the SRP as a result of your comments. We have added some more clarification. What we are looking for, you look at the reactor event database, the publicly available database.

And you go through and you can see numerous misloads. That happens.

MEMBER CORRADINI: Missed?

MR. RAHIMI: Misloads, mishandling.

MEMBER POWERS: Yes, yes. But what I am interested in is okay. I've got this thing. I think the burnup is X. And so now I wanted to make a measurement to confirm that.

And I am just assuming that a confirmatory measurement is not the kind of elaborate thing we have to do for actually calculating burnup credits and things like that.

MR. RAHIMI: Yes.

MEMBER POWERS: I am just wondering what

kind of a measurement it is.

MR. RAHIMI: Right. There are measurements, devices out there; fork detector, for example.

MEMBER POWERS: Say that again.

MR. RAHIMI: Fork detector. That's a system that has been developed, demonstrated for many years. It was originally developed by Los Alamos for the IAEA for the safeguard purposes.

VICE CHAIR ARMIJO: Is that sort of like a poor man's gamma scan or what is it?

MR. RAHIMI: It has got a gamma detector. It has got a neutron detector. It goes in there. You can take a sort of a scan of actual or you can go take a reading at a point.

It sort of gives you the confidence. Indeed, the reactor that you have, this reactor goes with this assembly. So it is not an independent burnup measurement. It doesn't. All it is is a correlation.

You take a neutron. You take a 60-second reading. Let's say you count 1,000 neutrons per second. You go back to your reactor reactors. You say, "Well, this assembly has got 33 gigawatt-days." And you do that for a campaign, whatever number.

You put it on a graph. This is my reactor record burnup. This is the neutron count rate. And you look at -- you see they correlate well. In some cases, in the case of Oconee, they demonstrated that. They found a couple of assemblies didn't correlate. They were off.

MEMBER CORRADINI: Just to follow that through, so that means --

MR. RAHIMI: Right.

MEMBER CORRADINI: -- that they weren't part of the batch they thought they were? That's all you'll be able to determine, is you --

MR. RAHIMI: That's right.

MEMBER CORRADINI: -- they have been mislabeled?

MR. RAHIMI: That's right.

MEMBER CORRADINI: Okay.

MR. RAHIMI: That's all it is.

MEMBER CORRADINI: But in terms of absolute burnup, you're not going to know?

MR. RAHIMI: No, no, you're not going to know because there isn't anything short of doing a destructive assay in terms of go --

VICE CHAIR ARMIJO: If the applicant can show you unambiguously that he knows the bundle ID and he's verified that by whatever method he chooses to use, whether it's an optical scanner, computerized so it's not relying on fatigued operators, he's got a very solid bundle identification.

Would you still require this additional measurement when he's got much better burnup data from his plant records to operate reactors relying on --

MR. RAHIMI: Yes, I believe that. I mean, the burnup number is the burnup in the reactor record that we are using, but looking at the history, the events that have happened --

VICE CHAIR ARMIJO: But that's history. That's history. And you can't ignore it, but I'm saying let's --

MR. RAHIMI: No, not history. I mean as recently as the 1120 assembly that were cooled less than the required cooling time in the cask. They were supposed to be --

MEMBER RYAN: Meraj, I think the question -- let's take that example.

MR. RAHIMI: Okay.

MEMBER RYAN: You have 11 elements that weren't cooled enough. Was there some defect in the identification numbering on that bundle that should have been caught that wasn't? What was the mistake that got them into that status?

MR. RAHIMI: Right. When you look at the reasons it varies, sometimes maybe the operator picked the wrong fuel assembly. Sometimes the records, over 30 years of storage, you know --

MEMBER RYAN: Here is what I think we're struggling with. So help us out. What I think I am struggling with is if I say I am going to take this bundle and put in a dry storage cask so I've got a method where I identify the number and that number is in the plant record and if I am absolutely convinced and sure that is the number, that is the one in the plant record, why do I need a confirmatory measurement when there is a lot of quality in the correlation in the plant record and that bundle number?

I'm stuck with why you have to do a measurement in that case.

MR. RAHIMI: Yes. Let me give Drew a chance. He wants --

MR. BARTO: This is Drew Barto, Spent Fuel Storage and Transportation.

I think where we are coming from with this measurement in looking to prevent misloads is plants generally do have well-determined burnup records that they use for operation of the reactor and also for storage in the pool. They generally have a high degree of confidence that the record that they have goes with this assembly ID number. And that's what we have heard over and over again.

The fact is there have been these instances that we have seen where there has been in some cases a large number of assemblies misloaded in seal-welded casks.

I know I can't speak for all the instances that we know of, but I know at least one instance was just misrecording the discharge date of the fuel assemblies, resulting in a shorter actual cooling time than the utility thought.

MEMBER RYAN: So it is not just the number ID on it. There are lots of other numbers that have to go into it. One is the burnup state of a particular bundle that you want to alter to put it in the cask.

VICE CHAIR ARMIJO: So you have no confidence in the quality assurance processes of the utilities. That's basically what I'm getting at. And I find that very frustrating because we load, unload, and shuffle thousands of fuel elements every year without independent measurements.

Of course, there is always a potential for misloading, but to assume or disregard the fact that if an applicant comes in and says, "This is my technique for verifying that I've got the right assembly. And if I can't verify it unambiguously using machines or whatever requirements you want, not separate measurement, if I can't, then I'll either give up burnup credit or I'll do your measurement for you," it seems to me you ought to give some recognition of a much simpler process that can be just as reliable as this ad hoc measurement.

And just going back to say, "Well, somebody made 11 -- misloaded some bundles a while back," I mean, we learn from mistakes. And you can put requirements on there so that people can say if you can assure she won't make this mistake, we can accept your reactor data.

MEMBER RYAN: Jack?

MEMBER SIEBER: Well, I know about a couple of misloadings, misidentifications. And I figure that the current fleet of reactors over a 40-year lifetime, not including life extensions, are going to be over a million fuel movements.

And you have already told us that there have been instances where misidentifications have occurred. Maybe you could put that in perspective for me by telling me roughly how many there were compared to the number of fuel movements that have occurred so far into spent fuel tasks.

And that will give me some idea as to how vulnerable we are to this kind of an incident.

MR. CAMPBELL: This is Larry Campbell. I am Chief of the Criticality,Shielding and Dose Assessment Branch. We are in the process of working with Research and Oak Ridge to revise ISG-08.

MEMBER SIEBER: Okay.

MR. CAMPBELL: And right now we are working on exactly what you said, the technical basis for the alternatives.

My background is quality assurance. I understand the comment well. But we have some analysis that shows with high burnup fuel, one misload at assembly -- and this is transportation -- might cause k-effective to -- you may go critical.

So we are working with Research. We have user needs' requests. And once we revise ISG-08, our next revision, we will be coming to the Committee with the revision. And at that time, we will have a pretty sound technical basis.

MEMBER RYAN: That is just transportation.

MR. CAMPBELL: That is transportation, but we have approved some applications where the applicants have proposed alternatives to misload, alternative to measurements. And we are taking that information. All of that is going to be rolled into the next revision of our interim staff guidance for burnup credit.

VICE CHAIR ARMIJO: Okay. Now if you don't have the transportation issue where you can have accidents, flooding, criticality, that wouldn't happen in just plain storage sitting on a pad somewhere. Would you have more flexibility? Is that your view, that you don't have a --

MR. RAHIMI: Yes.

VICE CHAIR ARMIJO: Risk is not the same.

MR. RAHIMI: Yes.

VICE CHAIR ARMIJO: Okay.

MR. RAHIMI: Right now the only reason we added this guidance, we said in case if a vendor wants to go after burnup credit knowing down the road they have to transport this storage cask and come in and get a transport certificate, the first question we would ask for transport is what kind of a confirmation did you do when you loaded this cask if you are using burnup credit?

So right now all of the casks that have

been loaded will burnup credit, no measurement in storage, they rely on the boron in the PWR pool. And that's what they have been doing.

VICE CHAIR ARMIJO: And the assumption is fresh fuel?

MR. RAHIMI: The assumption, it is a fresh fuel, yes.

MEMBER SIEBER: Isn't every cask eventually going to have to be transported somewhere?

MR. RAHIMI: Well, right. I mean, the utilities --

MEMBER SIEBER: I mean, it's not going to stay there forever.

MR. RAHIMI: But the utilities, they want to see how much money they are going to spend. Their issue is right now storage.

MEMBER SIEBER: Right.

MR. RAHIMI: You're right. You know, if they look far enough in I guess 40-50 years, whatever, if this thing has been transported off-site --

MEMBER SIEBER: Four hundred twenty years.

MR. RAHIMI: So you might want to really design a system that is transportable.

MEMBER CORRADINI: If I could just go back? I guess I was listening to this and -- so what you are really saying is that this guidance is primarily for those that want to take something that is now in stationary storage and want to ask for qualification to take that same cask without --

MEMBER RYAN: As is.

MEMBER CORRADINI: -- as is and move it.

MEMBER RYAN: Right.

MEMBER CORRADINI: That's the only time that this comes into play. I want to make sure I get that right.

MEMBER SIEBER: No.

MR. RAHIMI: Yes, yes. If they want to transport it off-site, they have to address this burnup verification.

MEMBER CORRADINI: Fine.

MR. RAHIMI: Yes.

MEMBER SIEBER: At least with casks, you have to do that for criticality purposes.

MR. RAHIMI: We do have cases right now in front of us that they loaded, specifically TN-40 at Prairie Island. They loaded 24 casks -- I don't know -- 10, 15, 20 years ago, storage only, under a storage license.

And now the State of Minnesota wants them to get a transport certificate before they let them load any more casks because they want to make sure that these are transportable.

Now we are looking at case of these are already loaded. They didn't do a measurement. The way we are handling it, we are handling it case by case. You know, we said, "Okay. What was your pool? What is your under-burned fuel?" We are looking at the probability for misload analysis.

MEMBER RYAN: Meraj, let me ask you a question at that point.

MR. RAHIMI: Yes?

MEMBER RYAN: If they have the loading records for the bundles and the certifications for each number, is there a way to evaluate that and use margin as the safety factor, as opposed to an ad hoc measurement? I mean, I am sure that is the road you must be going down.

MR. RAHIMI: Yes, right, precisely. That's --

MR. LORSON: That is what Larry had mentioned with respect to the user need with research. We want to look at what the database is because we do trust the reactor records, but we know that, despite the best reactor records and despite the best efforts of industry, we still have misloads.

The question, getting back to John's point, is I have a percentage of misloads through a total population of fuel, but how likely is a misload to occur?

MEMBER RYAN: This is really helpful additional conversation because it sort of leads me to believe that it might not be a ripe thing according to this version of the standard review plan, this guidance, because you don't know how it is actually going to come out yet. You're kind of hoping.

MR. RAHIMI: That is right. We are working, as Larry said, on the --

MEMBER RYAN: Now, is this something you should -- I'm just throwing an idea out here. Is this something you should not try and settle in this round of the standard review plan and deal with it as guidance after the standard review plan is issued? And then as it matures, the additional analyses, do you write a new ISG or revise the standard review plan again or --

MEMBER SIEBER: Well, another way to do it would be just to reference ISG-08. And then when you decide while you are working on ISG-08 to modify it, when you do that, then the new reference would still apply.

MR. LORSON: I think that is a good point. We could do that. We could reference the current ISG-08, revision 2 as our current review standard.

VICE CHAIR ARMIJO: Which does require measurements --

MEMBER SIEBER: That's right.

VICE CHAIR ARMIJO: -- either for transportation or for storage.

MEMBER SIEBER: That's right.

MR. LORSON: Right.

VICE CHAIR ARMIJO: The current ISG requires it for both --

MEMBER SIEBER: Right.

VICE CHAIR ARMIJO: -- or fresh fuel assumption or no burnup.

MEMBER RYAN: You know, that seems to me to be a way forward here that doesn't leave you with a potential thing you'll have to go back and revise quickly or put some guidance about it.

MEMBER SIEBER: That, and it's easier to revise one thing than two.

MEMBER RYAN: Well, then cleanly reference the revised ISG-08 when that work gets done.

MR. LORSON: And we will come back and again present revised ISG-08 more complete. And then we'll be able to, I think, more fully engage in the discussions. We will have found the analysis of the data that is out there.

MEMBER RYAN: So if the grownup credit measurement in the current draft of the plan was changed to reflect that thinking, that would probably solve, I think, Sam, the questions we have discussed at some length.

VICE CHAIR ARMIJO: Yes. It just seems that there are practical alternatives that rely on unambiguous identification of the assembly.

And granted that some people have made mistakes in the past. I think that is sloppy QA or maybe they just -- I don't know why they did it, but they did it.

But it doesn't have to be repeated. We do learn. And if somebody says, "Hey, there's a benefit to doing this right" and they convince the staff, they really can identify the assembly, then --

MEMBER SIEBER: Even though we are smarter now than we were yesterday, once a mistake is made, that mistake carries on forever.

MR. LORSON: Correct, particularly in the case of loaded canisters because people are typically --

MEMBER SIEBER: This has been going on for 25-30 years or more.

MEMBER RYAN: We have gone well past our time. Unless it's on a pressing, burning question, I would like to --

MR. RAHIMI: Okay. So the comment, I guess, Dr. Ryan, I sum it up, is maybe it is better to do it by reference in the SRP, reference to the ISG, as opposed --

MEMBER RYAN: And that way the SRP is clean. And then the reference can be updated and modified to reflect better thinking as you complete your studies.

MR. RAHIMI: With the entire discussion of burnup credit or the measurement? Because, as you know, ISG goes through the entire methodology. And measurement is one part of it.

MEMBER RYAN: Right.

MR. RAHIMI: I mean, so do you think it is a good idea that the entire discussion on the burnup credit for storage casks for, say, see --

MEMBER RYAN: I'd defer to, Sam, whatever you say you think is --

MR. RAHIMI: That's what ISG --

VICE CHAIR ARMIJO: I just think it comes across to me as an unreasonable requirement in that there is no alternative that the staff would even consider that would rely on something that is more practical.

MEMBER RYAN: I think if we resolve it in the ISG, it's a much cleaner way to leave the SRP.

MR. RAHIMI: Okay.

MR. LORSON: Okay.

MEMBER RYAN: If that works for you, I think we have reached a good discussion point. Thanks for your indulgence on the extra time. I think it was well-spent.

MR. RAHIMI: We will go back and look at it. And if we have any sort of concerns or anything, we will bounce it off of you, what you think, you know.

MEMBER RYAN: Sure. Thank you.

MR. RAHIMI: All right. Thanks.

MEMBER RYAN: One last ten-second comment. I want to thank the staff for a very engaging couple of and very productive subcommittee meetings and, again, some good discussion here. Thank you very much for your time and your thoughts.

MR. LORSON: Thank you for your comments. It certainly helps us achieve a common goal, which is to make the document as good as we can.

MEMBER RYAN: Thank you, Mr. Chairman.

CHAIR ABDEL-KHALIK: Thank you, Mike. Okay.

We will take a ten-minute break. We will reconvene at 10:00 o'clock.

(Whereupon, the foregoing matter went off the record at 9:47 a.m. and subsequently went into executive session and went back on the record in open session at 11:35 a.m.)

4) MEETING WITH THE NRC CHAIRMAN

4.1) REMARKS BY THE ACRS CHAIRMAN

CHAIR ABDEL-KHALIK: We're back in session. We are very pleased to have with us Chairman Jaczko, who would like to just meet with the Committee and discuss some items of interest.

4.2) DISCUSSIONS WITH NRC CHAIRMAN GREGORY B. JACZKO ON TOPICS OF MUTUAL INTEREST

CHAIRMAN JACZKO: Great. Well, I thought I would just go through a couple of things and mostly take questions. Perhaps that way we will focus in on for sure what is of interest to you.

But I guess if I could just say this is really, really a privilege for me to be able to address this group. Your work is tremendously valuable to this agency. And over the decades this agency has existed, the ACRS has really been, I think, one of the shining examples of the excellence of the NRC structure and the organization that we have in place.

We obviously now have a little bit of that more directly on the Commission as one of your former colleagues is now one of our current colleagues. So we are privileged, and I suspect that will give us an even greater insight into the workings and the areas of interest and focus and attention for the ACRS.

What a very interesting time in the NRC's history. We have a lot of potential new things that we could be doing, a lot of potential new ways of doing things.

At the same time, we are really looking at a reactor fleet that is probably close to or more than halfway through its life realistically. And at the same time, we are looking at starting a whole new potentially wave of reactor licensing and potentially construction in this country.

So it is a very interesting time, I think, to look at what kinds of changes and what kinds of regulatory improvements do we need or should we be making and when do we need to do them.

You know, a good example of that, something that I look on as potentially on the Commission's horizon, is the 50.46(a) rulemaking for risk-informing the loss of coolant accident. And you heard at a Commission meeting, I think, on a slightly related topic Commissioner Magwood talk about that and what role that would play with resolution GSI-191.

I think, in general, the more interesting question is what role would risk-informing the ECCS rule have right now? And I'm not sure that it has one.

If you look at the existing reactor fleet, I am not sure that licensees are interested if -- again, these are the kinds of things I think are interesting questions -- is a reactor that may be in year 45 or 46 or 47 of operation going to want to go through and do a license amendment to implement ECCS rule change for potentially an additional 10 or 15 years of operation. I think those are interesting questions.

And, of course, the current fleet of reactors that we're looking at reviewing licensees for right now is being licensed to the old rule.

So it is just an interesting question about where we will go with some of these kinds of changes and whether we will really see, as we do these kinds of rules, as voluntary rules, whether we will see licensees move forward.

My preference on a lot of these things is, quite frankly, I think to do them is mandatory -- I always think it is kind of an oxymoron -- is to do them as mandatory rules if we are going to do them.

If this is the right way to deal with safety, then I think that is what we should be saying and that is what we should be doing.

Coupled with that, of course, is the work that is going on on fire protection. And you look at a rule like NFPA 805, which was a risk-informed rule, a performance-based rule, and not maybe half the fleet right now is looking at moving forward with that rule. The other half would at this point.

And, with the new fleet, they have taken from a design perspective the appendix R concepts and built more of those appendix R concepts in. So, at least from what I have heard recently or recent by about a year, year and a half at this point, that is not a rule that new reactor licensees would intend to pursue.

So it raises some interesting questions about some of these initiatives in this approach of voluntary rules and what the future really holds for these risk-informed approaches to things. I think there is value in them, but I am not sure that, despite what we hear from licensees, the industry yet sees the value in them because there is still some hesitancy about wanting these to be mandatory rules and, still, I think a preference for voluntary rules as we go forward.

Of course, we can look at other rules, risk-informed rules, the Commission has put into place that have not yet been fully utilized. Special treatment is still not one that we have a licensee that has come forward to use that rule.

So it is an interesting, I think, insight into risk-informed regulation. I think where risk-informed regulation has been particularly viable is in the oversight of the plants from our perspective and I would say kind of from the oversight of the plants from the licensees' perspective.

So from a maintenance standpoint, looking at maintenance activities and looking at that from a risk perspective has been a tremendous I think tool and resource and improvement and enhancement to safety.

So it may be the risk-informed program is not a rulemaking program, but it's more of an oversight program perhaps. I think those are just some interesting things I think that it will be very interesting just to see how we and the industry really deal with those things going forward.

So it is a very interesting time, I think, for the agency right now. Of course, one things the Commission recently met about is the fuel cycle program and trying to do some things on the oversight and the fuel cycle program to better put in place an oversight program that is more comparable to the ROP in the virtues, I would say, more than in the details, so namely an oversight program that is transparent, that is predictable that meets those kinds of traits and hallmarks that we have for the reactor oversight process.

So I would just close briefly with two other items, one of which I think again is a very interesting issue for this agency and one that is a very interesting regulatory topic. And that is safety culture and what role safety culture is ultimately going to play in regulation or in oversight for the NRC.

The NRC is at a point now where we are working on a policy statement to address safety culture and look at safety culture issues. That policy statement I hope to have finalized in about a year.

At the same time that we are doing that, in the reactor side, we have the work that we do in the reactor oversight program to look at safety culture in our review of essentially green findings. And then we also have a pilot program that the industry has started right now to look at safety culture in a very different way.

So I think that will be an issue that will generate a lot of discussion and a lot of interesting policy work for the Commission in the next several years. And you can see a multitude of avenues.

I think right now, speaking for the industry, I would say what I am hearing from them is that they would like to see the pilot become a more definitive aspect of safety culture in that we would altogether eliminate the cross-cutting aspects of the reactor oversight process in lieu of a new safety culture program.

I am not necessarily sure that that is the right approach, but there may be some things that we can do to look at what we are doing with cross-cutting issues and seeing if that is really the right approach to dealing with safety culture.

So that would raise some interesting questions in general about the ROP and how the cross-cutting issue program works, particularly at a time when we are moving, I think, more and more away from the infrastructure issues to the human performance issues.

And I think that is why safety culture is probably getting more and more attention because, as we look at performance challenges, we see more and more that those performance challenges are in the human performance areas.

You know, equipment performance is getting better and better understood. Obviously with more and more years of experience in watching these plants operate, we have a better sense of how equipment performs and what those issues are. So I think that will be an interesting issue to watch out for in the next couple of years.

The last thing, I again would just say that I think ACRS does set a tremendous tone for this agency. And your objectivity, your technical expertise, your inquisitiveness, I think these are really all parts of this organization. And it really adds a tremendous dimension to the agency's ability to make sound decisions. And I think it will be interesting to see work that you produce in the coming years and the coming months.

With that, I thought I would stop. And feel free to ask me any questions. I would be happy to answer anything.

MEMBER RAY: Well, Mr. Chairman, let me say that having been a licensee when risk-informed regulation was in its formative stages anyway, oversight was the major aim, not rulemaking, primarily because risk-informing goes beyond the design basis. So there's always two edges to the sword.

So it's not surprising that credit pays off and value probably emerges in the realm of oversight, rather than other applications.

CHAIRMAN JACZKO: That is an interesting insight. I appreciate that.

MEMBER POWERS: It seems to me risk-informing things like 50.46 -- and I will tell you that it's both (a) and (b). In fact, (b) is more important than (a) because you do want to keep your fuel intact -- that you're really trading in the area of the interface between PRA and your defense-in-depth concept.

The two of them have an uneasy

relationship between each other. And it requires a philosophical point of view on that, classically described as structuralist or rationalist.

Does the Commission have a structuralist or a rationalist point of view?

CHAIRMAN JACZKO: I think Commissioner McGaffigan was fond of describing himself. I think he would have said that he was. I am not sure that we do. Perhaps we do now, but --

MEMBER POWERS: Well, you have got one strident rationalist.

CHAIRMAN JACZKO: Yes.

(Laughter.)

CHAIRMAN JACZKO: So, you know, it does come down a lot. I think you, as usual, hit the nail on the head. It is that balance. And I would maybe say it in another way. It is the balance between risk-informing and risk-basing, perhaps gets to your same issue of to what extent the risk becomes the dominant decision-making factor versus an element of looking at our regulatory program and the concept of defense-in-depth. And I think that that is the uneasiness.

I don't know where the current 50.46(a) rule is because it has just been a while since I have looked at it, but as the rule initially came up, I think that was one of the issues that we really looked at is how -- and I think that the industry looked at it from that perspective, too, was were we keeping too much defense-in-depth in there to the point where we lost what the rule was trying to accomplish.

And so I don't know from a technical standpoint where the meat of the rule is right now and whether that has changed or if it's appropriate for the change. But I think it is interesting. That is a very important issue.

I remember having a conversation with former Commissioner Lyons after he and I had been here shortly and he went to the RIC. He got asked a question. He was asked a question about risk-based regulation, what did he think about risk-based regulation.

Of course, being new to the NRC, that was a bit of a loaded question. And I think he said he thought it was a good idea, not recognizing that it was -- he was thinking risk-informed. And what they were saying was risk-based.

As we do more of it, it is a very, very difficult area. Now, of course, we look at the Commission's policy statement on risk-informed regulation. And it's clear in the policy statement that risk tools are there to inform and enhance the deterministic and the defense-in-depth concepts and to enhance the decision-making process, not to replace necessarily. But, again, I think it's the --

MEMBER POWERS: I mean, that raises another issue. The way that is written, as you say, to enhance, it can easily be interpreted as risk information is only used to ratchet requirements. And certainly that is the way it is interpreted by many in Europe. I don't think we do.

CHAIRMAN JACZKO: We ratchet which way?

MEMBER POWERS: More. You have more stringent requirements. And I don't think we do, but I know that that wording can be interpreted by many, including one of your recent colleagues, as a basis for only using risk information to increase requirements.

Myself, I see it as the move has been to bring more of the plant under regulatory control because we have found from painful experience that things that have not been classified as safety systems interact with safety systems. And it is a system and not a set of components and trains.

CHAIRMAN JACZKO: It is just fascinating, actually, to hear that because it is interesting in this country, certainly I think in the public interest community -- that's why I asked whether you meant ratchet up or ratchet tighter, ratchet looser. I think they would say exactly the opposite, --

MEMBER POWERS: Oh, yes.

CHAIRMAN JACZKO: -- that is there as a way to relax standards and relax requirements, which, again, some of the challenge in this area is -- and I would point to NFPA 805 because fire protection is a regulation -- I always tell people I know what basically the -- I mean, generally I can tell you what the basic requirements, performance requirements, are in 50.46(a) as well, but fire protection is a simpler one in a lot of ways.

At least the appendix R plants, it's basically 3 requirements: 20 feet of separation. You don't have that, three-hour barrier, or a one-hour barrier with suppression detection. And I always point to that. I can remember it. So it's pretty simple.

And then you transition to something like an NFPA 805. It's much more complex to explain to the public how that whole process works and where the role of risk information, what it means to be a performance-based rule.

And now, of course, NFPA 805 is a framework. And it includes within that framework a deterministic approach as well. So that one is even in many ways not a strict risk-informed rule in that regard, but it allows the use of risk information in a way that the current rule doesn't.

But that is a very difficult issue to not only explain to the public, but I think even sometimes to explain within our staff and within the agency of how those things are to be dealt with and used.

And so these are challenging areas, but I think, as I have said quite a lot lately, this is the first year we won't have a reactor plant at the AARM, I think since the beginning of the ROP.

One would I think want to attribute that to the success of the ROP, of the risk-informed aspects of the ROP, of that oversight role of making the plant safer and fixing the issues that really matter so that to the point where we don't have to have a plant that comes to the AARM meeting in front of the Commission.

So I think that is certainly an interesting situation, but I think there will be challenges with this for a long time to come until we would ever -- you know, the simplest thing in a way is probably to at some point have Congress say that "No. You truly are a risk-based agency." Then it would solve all of these difficult decisions.

As it is now, it is just something that we have to figure out where that -- what is risk-informed versus risk-based and how do we make sure that we do that in the right away that preserves safety, which is what we have to do.

MEMBER BLEY: Mr. Chairman, I kind of think of it a little differently. As a rationalist, it seems to me if you take that approach, there is a responsibility attached to it that is kind of unique compared to the other areas that require some real honesty in looking for the unusual things and trying to account for what you don't know, which always brings you back to some kind of a mix between the two.

CHAIRMAN JACZKO: Yes.

MEMBER BLEY: Your opening statement was interesting to me. I almost think the opposite. With 50 percent of the plants going ahead with 805, that is a surprisingly high number to me and especially because they're moving into uncharted territory, which always is something difficult to do.

You mentioned none of the new reactors are going that way. I might be missing this, but I thought what I read and what staff has told me is that 805 is not available to the new reactors before they are certified and get the COL. Is that wrong?

CHAIRMAN JACZKO: Well, I would tell you what my understanding is. And I guess my number may not be quite right on 50 percent of the plants.

MEMBER SIEBER: That is about right.

MEMBER BLEY: That is what we have heard, too. Yes.

CHAIRMAN JACZKO: And I would say why it's not about right is it's intent right now, but there is some --

MEMBER SIEBER: Yes.

CHAIRMAN JACZKO: -- grumbling about maybe pulling back on that intent. I hope that doesn't happen, but I actually hope that the number goes up. I think the reason is more because the current program is intractable for many plants. They don't have another way to go forward.

The issue of new plants, I think yes, it's true that NFPA 805 does not by rule or by the standard itself cover new facilities. And there was I think at some point discussion about an NFPA 805(b) or (a) or 806 -- I think they called it 806, getting my (a)'s and (b)'s and numbers mixed up, but it was an 806 that would have addressed new plants.

MEMBER BLEY: But doesn't as yet, yes.

CHAIRMAN JACZKO: But doesn't as yet, yes. But I think the idea was that the new plant simply didn't need it because it was simple to do at a design stage to just design it correctly. And you didn't need the infrastructure then. And it wasn't such a burden that you even had to think about going that way because you could just do it from a straightforward standpoint.

MEMBER POWERS: One of the biggest issues that I suspect we will encounter is just the training of personnel because the nice thing about appendix R is that you can remember exactly what you're trying to -- which is really preserve one train of safety system.

CHAIRMAN JACZKO: Right.

MEMBER POWERS: And it's very simple. And the licensee is actually invested very heavily to get their staff trained. Now you're asking them to train in something that is much more complicated and less than intuitive.

CHAIRMAN JACZKO: Yes.

MEMBER POWERS: And I suspect that is

going to be the challenge.

CHAIRMAN JACZKO: And it is an underlying cost to these voluntary rules that we have now introduced within our training program potentially the need to train not only people in the deterministic approach but also in the performance-based approach as well. And so it does increase that burden and the ability of making sure we have enough appropriately trained staff. It's a very good point.

MEMBER SHACK: I was just curious. Your comments of a plant in its 45th year only had 15 years to look forward to. You don't think that people are going to be coming back for life beyond 60?

CHAIRMAN JACZKO: I don't know. I honestly don't know at this point. But I would speculate that we are probably not looking at life beyond 80, for sure.

(Laughter.)

CHAIRMAN JACZKO: And so I think it is pretty sure that we are probably over the hurdle. And I don't know. It will be interesting to see whether at that point we will move.

If we're talking, say, 15 years from now a plant that is in your 55th year of operation, maybe they have come in for license renewal. Maybe that licensee has decided at that point there is a more stable -- I shouldn't say stable but that there is a proven track record of construction for new units. They may then at some point decide to make those decisions and at some point begin decommissioning.

So I don't know. I don't know where that endpoint is. I don't know. I think I asked Dana once in a meeting if there was a showstopper beyond 60 that we know of right now. And I think you told me you didn't think there was.

MEMBER POWERS: Well, vessels.

CHAIRMAN JACZKO: Vessels, yes.

MEMBER POWERS: Vessel embrittlement on the PWRs. It's less of a concern on the BWRs.

CHAIRMAN JACZKO: Yes.

MEMBER SIEBER: Yes, heavy --

MEMBER POWERS: So you are going to have to do something on several of the vessels, not all of them, but several of the vessels will run into a problem eventually.

You also run in from a policy point of view, your world, it's the airplane problem. We really don't want to be flying 707s now that they serve over civil aircraft and whatnot, but the modern aircraft are much, much better.

CHAIRMAN JACZKO: And it is interesting because that discussion is very vibrant right now in the international community, --

MEMBER POWERS: Yes.

CHAIRMAN JACZKO: -- much more so than in this country. And as I go to speak internationally, that's a question that I am often asked. There is I think a discussion internationally brewing about should there be a standard that would basically lead you to saying that older facilities should be phased out because they are not at the same level of safety or I shouldn't say same level of safety but are not at the same level of inherent design safety.

And generally my response is looking in the United States. We have minimum safety essentially requirements. And all plants have to meet that, whether they are new or old. The old ones don't or if the new ones don't meet it, then they don't operate. It doesn't matter the age, but it matters what the requirements are.

But there is a discussion internationally. And some of that I think has to do with the dynamics of different types of reactors in different fleets and different generations that have led to that discussion happening.

But I suspect that that will only gain attention in time and that people will eventually start to ask those questions, should we be continuing to fly the B-52s or go back 50 years? And, again, the B-52 that is flying today is not the same B-52 that flew 50 years ago, --

(Laughter.)

PARTICIPANT: Maybe the same color. That's about it.

MEMBER POWERS: Even that has changed.

CHAIRMAN JACZKO: -- of the current fleet of reactors. Nobody is going to have their original steam generators. And right now it seems like the vessel will be the issue. And what can be done with that? That will be I think an interesting question.

So I haven't seen an applicant yet for a 60-year operation, 60 to 80-year operation. Now, of course, we have three or four that are eligible at this point. I think Ginna. Is it Ginna or --

MEMBER POWERS: Ginna surely must be one, yes.

CHAIRMAN JACZKO: Oyster Creek definitely. We have got a couple that are in operation at this point. So they are eligible under the rule for relicensing now.

MEMBER POWERS: Ginna, of course, is a relatively small plant. And some of the others that are eligible had challenging license extensions to begin with. And so they may not be the points on making the transition.

(Laughter.)

CHAIRMAN JACZKO: Yes. Well, I apologize that we don't have more time for this discussion, but it has been very enjoyable so far. And, again, I just want to thank you for all the work that you do and look forward to meeting, I think, coming up in --

CHAIR ABDEL-KHALIK: Next month.

CHAIRMAN JACZKO: Next month?

CHAIR ABDEL-KHALIK: Yes.

CHAIRMAN JACZKO: And we will have an opportunity to dialogue with you. And obviously the full Commission will be there as well. So thank you.

CHAIR ABDEL-KHALIK: Well, thank you for coming. We do appreciate it.

CHAIRMAN JACZKO: Thank you.

CHAIR ABDEL-KHALIK: At this time we take a break for lunch until 1:00 o'clock.

(Whereupon, a luncheon recess was taken at 12:03 p.m.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

(12:58 p.m.)

CHAIR ABDEL-KHALIK: We are back in session. At this time we will be discussing the staff's proposed guidance for the use of containment accident pressure. Dr. Shack will lead us through this discussion.

5) BWR OWNERS GROUP (BWROG)

TOPICAL REPORT NEDC-33347P

5.1) REMARKS BY THE SUBCOMMITTEE CHAIRMAN

MEMBER SHACK: At our April 22nd meeting of our Power Uprates Subcommittee, we covered two related topics. One topic was the licensing topical report from the BWR Owners Group on containment overpressure credit for NPSH.

The topical report is intended to provide a more standardized and predictable approach for use by applicants in requesting credit for containment accident pressure. It retains the use of a conservative, bounding, deterministic calculation for licensing but also includes a statistical approach that addresses uncertainty and variability through the use of order statistics.

The statistical calculations are consistent with prior ACRS requests and are intended to provide insight into the actual margins available for design basis LOCAs.

The other topic discussed at the Subcommittee meeting was the new draft guidance on containment accident pressure developed by the staff. The Committee has written several reports documenting disagreement with the current guidance on containment accident pressure. And the draft guidance is the staff's attempt to improve that guidance.

Since a final judgment on the BWR Owners Group can only be made after the guidance is finalized, the subcommittee decided that the presentation to the full Committee should focus on the staff's guidance. We will be preparing a letter giving our views on the proposed guidance.

The draft slides we have just received indicate that the staff is proposing some changes in the guidance that we discussed at the subcommittee. And they have attempted to address some of the issues with the proposed guidance that were raised at that meeting.

We have received a request for telephone participation from TDA and the NRC staff at the regions. My understanding is that those lines are now open. They're in a listen-in mode only to preclude interruption of the meeting.

Sher Bahadur of the staff will introduce the staff's presentation. Over to you, Sher.

MR. BAHADUR: Thank you, Dr. Shack.

5.2) BRIEFING BY AND DISCUSSIONS WITH REPRESENTATIVES OF THE NRC STAFF AND THE BWR OWNERS GROUP

MR. BAHADUR: Good afternoon. My name is Sher Bahadur. And I am the Deputy Director, Division of Safety Systems in the Office of Nuclear Reactor Regulation.

As Dr. Shack mentioned, we are here to discuss the use of containment accident pressure in calculating the available net-positive suction head, NPSH as you call it for the emergency core cooling and the containment heat removal pumps.

After getting the letter from the Committee on March 18, 2009, the staff took a more detailed and comprehensive approach to the issues of using containment accident pressure in estimating NSPH margin. We are here today to discuss with you the result of our effort, which has resulted in a draft guidance, which, of course, I will represent to you.

You will notice three significant aspects of the approach the staff has taken: first, the information provided to us by the two recognized experts in the pump cavitation and NPSH; second, the extent to which the staff performed its own calculations to study the issue; and, lastly, a new approach to assess the risk of using containment accident pressure.

As you will see in this slide, the staff has come to Committees several times in the past. We have discussed this subject with you several times and got your comments as and when we came here. Several times you also came and presented to you site-specific issues and also the generic issues, as you see in the slides.

Your March 18, 2009 letter made five specific recommendations for us for treating this issue. And that letter and also the previous discussions with you led the staff to examine the issue from both a risk as well as a deterministic perspective. We have attempted to better quantify the risk and the deterministic margins, as you will notice.

Also, when we came here and based on the comments made by the Committee, we suspended the review of using the containment accident pressure for the two EPU applicants while we address your concerns. So if the guidance is okay with you, then, of course, we will proceed accordingly.

After receiving the March 18 ACRS letter on the use of containment accident pressure, the staff undertook a study of the issue. To assist, we consulted with two experts in cavitation, NPSH, and pump hydraulics. If you need more details, the staff will later be able to provide you that.

The staff performed calculations primarily to better understand the sensitivity to the important parameters, to assess margin, and to understand the effects of the guidance that we are proposing.

We have also studied the risk of using containment accident pressure using staff analyses. We had previously been in the mode of reviewing the analyses provided to us by the licensee. Later on the staff has also developed their own analyses. We examined the risk from the perspective of necessary guidance to ensure that the risk remains low.

The Committee had a meeting with the Commission in which you mentioned the containment accident pressure and other topics. As a result, on June 8, 2009, the Commission issued a staff requirements memorandum directing the staff to continue working to resolve the differences between the ACRS and the staff concerning containment accident pressure. So today we present to you the material based on which we believe that we have met the requirement of that SRM.

So today's presentation will be in three parts. The first part would be the risk evaluation, followed by the presentation by the industry on containment integrity. And, lastly, we will present to you the draft guidelines.

The draft guidelines reflect feedback from the Power Uprate Subcommittee that we had with you on April 23rd. And, as Dr. Shack mentioned, we certainly would appreciate a letter reflecting your views on this particular topic.

Our discussions with the industry and with other stakeholders have just begun. After considering ACRS and the stakeholder comments and finalizing the guidance, we would resume the two EPU reviews which are now on hold. Also, we intend to publish an interim guidance document. The final document will be the revision of regulatory guide 1.82.

So, with that, if there is no question for me, then I would like to proceed with the presentation. Marty?

MR. STUTZKE: Good afternoon. I am Marty Stutzke. I am the senior technical adviser for PRA technologies in the Division of Risk Analysis in the Office of Research.

I have two presentations for you. The first one is basically a recap of what we discussed in the subcommittee meeting about how we have gone about trying to estimate the risk of containment accident pressure credits.

The other presentation is application of the insights we learned from this to our process here.

MEMBER STETKAR: Marty, when you move your paper, just be careful of the microphone up there.

MR. STUTZKE: Got you. So we'll start out with an overview, talk about the technical approach and some level of detail, perhaps not as much as we were able to cover it at the subcommittee meeting like this.

There are some new things that have been done since the subcommittee meeting. One is some considerations of how operator actions would affect the risk results. The other thing is a simplified what I believe to be a conservative estimate of the seismic risk contributors like that.

So basically we took a couple of our plant SPAR models, standardized plant analysis of risk models, and revised them in order to reflect the containment accident pressure credit.

And the assumption was for the Browns Ferry and the Monticello models is that the credit is need whenever -- these are the core spray pumps. The RHR pumps are taking suction off of the suppression pool.

That is probably conservative based on what we have seen, for example, at Browns Ferry and at Vermont Yankee. So they don't necessarily require the credit on all types of sequences like this.

As I have indicated before, we have added a seismic analysis that is based on simplified methods for being used to help look at generic issue 199. That issue is concerning increased seismic hazards in the central and eastern United States. And I am heavily involved in that as well.

It is simplified because of the assumption that a loss of containment directly leads to core damage for all types of sequences. So that is pretty bounding.

MEMBER STETKAR: Marty, I wasn't at the subcommittee meeting. If your HCLPF is .3 g, you're meeting capacity up around .78?

MR. STUTZKE: We will get to that, but yes, it's about -- yes. This is new material the subcommittee hasn't --

MEMBER STETKAR: Okay. Thanks.

MR. STUTZKE: Yes. But yes, you're right. It's about .7 g.

So in order to get started in the analysis, we need to understand the definition of loss of containment integrity. And it simply means the containment is leaking enough to prevent adequate NPSH.

The actual leak size, of course, would need to be determined through some sort of thermal hydraulic analysis. I've given you here on the viewgraph what has been used in previous licensee-performed PRAs, 27 La at Vermont Yankee, maybe up to 60 La when you use more realistic assumptions. Browns Ferry, there is a flat 35 La. I picked 20 trying to pick a lower bound to drive the core damage increase up higher, like this.

So the model assumes three time frames: pre-initiator, upon-initiator and post-initiator type. And we have tried to look at all of the contributors to each one of those.

The pre-initiator leak probability -- what licensees had done in the past is to go to an EPRI document. You see the number there. And it's based on spending integrated leak rate tests on the containment from three tests in ten years to some less frequent testing regime.

What they had done was to simply extract those numbers out and substitute them into their risk models like that. At the same time, we all realize that there are other ways of protecting containment leaks besides integrated leak rate tests, notably for BWR with Mark 1 containments, they are being inerted. And the loss of inerting would be an indication that you have a leak of some size. So we wanted to get after that and realize the probability of the leak should depend on how the containment integrity is being tested, not only how often but how good is the test at actually finding leaks of the size we need to preclude NPSH.

That led us to develop a semi-Markov model to try to put all of the ingredients of this estimate together. We will talk briefly about what that is in a few more slides here.

So basically what we did was to model a hypothetical tech spec, as you see, like this that basically says if the containment leaks at or above a certain level -- in our base case, it's 20 La. Then the required action is stop the leak, and you have 24 hours in time to do it.

If you don't get that done, then you need to shut the plant down. And you have an additional eight hours. Then the frequency at which you would test the containment leakage is assumed to be seven days.

Now, all of these parameters, we have varied. We have done pretty exhaustive sensitivity studies to try to get a feel for did it really make any difference or not?

MEMBER CORRADINI: Can I just clarify the T1?

MR. STUTZKE: Yes.

MEMBER CORRADINI: T1? Whatever it is at the very bottom. T1?

MR. STUTZKE: Right. That is the test interval.

MEMBER CORRADINI: Okay. That means now you determine you are leaking. Now you are trying to solve it. Now keep on testing until you --

MR. STUTZKE: No.

MEMBER CORRADINI: No?

MR. STUTZKE: That means every seven days you test to see whether or not you have a leak. And if you have a leak, then you jump to the top part of the table. And then you have 24 hours to resolve it.

MEMBER CORRADINI: Okay.

MR. STUTZKE: For example, in integrated leak rate tests, this could go up to 15 years in 7 days. That was the way we were testing the integrity.

MEMBER CORRADINI: Thank you.

MR. STUTZKE: So pre-initiator leak probability depends on a variety of parameters: the leakage failure rate; the mean time to repair of the leak; the surveillance test interval, TI; the allowed repair duration while you're at power, TST; the mandated shutdown time, TSD; and test sensitivity.

We'll talk about the test sensitivity in the context of statistical hypothesis testing. When I went to school, this was known as the test confusion matrix.

The notion is this, when you test something, the test is not perfect. And it might be unable to detect what you hope the test to detect.

And there is a variety of combinations. You are probably familiar with the concept of false positives, in this case where the containment is actually intact but the test indicates that it is leaking. That is a concern for operations because now the plant would be chasing down a tech spec for no real purpose like this.

What is of concern to us in the safety and for the preexisting leak probability are the false negatives, where the containment is actually leaking but, in fact, the test indicates everything is okay.

So when you put your information together, you end up with a semi-Markov model. And I will go through the various states of the model and their transitions.

Basically what a semi-Markov model does is assume that the containment has a variety of discrete states. It can be intact. It can be leaking undetected. The leak could occur at power and while it is being repaired and so forth.

So, to try to give you a little bit better feel of how that works, we can define state 1 as intact containment. We realize if a leak occurs that has some probability of occurrence, it jumps into state 2, which is the undetected leakage state. Similarly, a leak may not occur. So it remains in state 1. And that is what the closed loop back on itself refers to.

Given that the leak is undetected, eventually you conduct the test that would detect the leak. And that has a probability of one minus beta in this model like this.

If, in fact, the leak is detected, you enter the action statements of the tech spec. And you start your at-power repair time like this. Similarly, the test may let you down. And it won't find a leak that actually exists. And so it would remain in state 2.

If the at-power repair is successful, it's effective. The process jumps back into state 1. We have to allow for the possibility that the repair gets completed but, in fact, didn't remedy the problem.

And so then it jumps back into state 2 and so forth. The repair power is not completed. Plant transitions to shutdown. And the repair is either successful or it's not like this.

All of these states refer to at power or critical operation states. If you wanted a more comprehensive model, you could worry about the probability of repair during shutdown of the thing, but that is irrelevant to calculating the probability that we need.

I should also point out that I have some backup slides that provide a little bit more description of semi-Markov processes and how they work and some more of the model parameters.

Basically what is important to realize here is that the probability of the preexisting leak is the long-run fraction of time that the system spends in states 2, 3, or 4, like this.

So that is various parameters that we have used to quantify the model. The failure rate of a 20 La leak was estimated at about 10-7 per hour. And you can see the sources there where we came from to derive this type of estimate.

Similarly, the mean time to repair of these leaks, this is presumed to be 72 hours like this. It is interesting to note the leak rate at 1 La is much higher than it is, for example, most of the LOCA frequencies that we would consider in a PRA like that.

So when you put all of this together -- and if any of you are familiar with Markov models, you realize this is a matrix problem. And so you can solve it. And we determined the preexisting leak probability, as shown by the series of curves like this.

This is showing you sensitivity to a number of parameters. First of all, you will notice the strong dependency on the surveillance test interval TI, where if you approach the lower left corner, where the testing is once per hour, it is virtually like a continuous monitored containment leak, all the way up to some very large times of ILRT, once in 15 years or 3 times in 10 years, something like that.

You will see the graduations between the blue lines and the red lines on the graph there that are showing you different testing sensitivities like this. We assume first the bottom line is a perfect test that always finds a leak up to about a five percent chance that it can't find the leak.

To put that number in perspective, 5 percent is one out of 20. If your car were that unreliable, you would throw it away. That's like it would fail to start once every two weeks, something like that. So that is a pretty good test, achievable. So I have tried to bound it like that.

We also did some sensitivity studies looking at how we could alter the tech spec times, the mandated shutdown time, the allowed at-power repair time, up through some reasonable value of ranges. And you can see it does change the values when you get down to much frequent testing, but up beyond testing once a week or perhaps once a month or something, these parameters don't have a great deal of influence on the model.

This one shows you sensitivity to the preexisting failure leak rate here, the top curve being a leak rate at 10-6 per hour. The bottom curve is our baseline number.

MEMBER CORRADINI: Maybe you said it. The baseline number is from where?

MR. STUTZKE: That comes from this set of data.

MEMBER CORRADINI: Oh, okay.

MR. STUTZKE: Okay. So that is --

MEMBER CORRADINI: From the "set of data," meaning that you already know from previous testing what 1 La is and then you are extrapolating to --

MR. STUTZKE: Have to scale it up.

MEMBER CORRADINI: Okay. Thank you.

MR. STUTZKE: With respect to the upon-initiator leaks, we can look at containment isolation as an obvious failure mode. During power operations in a mark 1 containment, of course, there are no direct open pathways between the containment and the atmosphere.

Otherwise the nitrogen would go someplace. But we realize the fact that there are pathways during the initial inerting of the plant or the de-inerting of the plant -- and so it is necessary to weight the pre or the upon-initiator leak probability of 10-3. That's a good number for containment isolation failure, the fraction of time that the plant spends with one of these pathways open like this.

This is different than what had been done before at Browns Ferry or at Vermont Yankee, where the licensee had assumed that containment isolation is always required.

Another thing that we learned during the Vermont Yankee EPU submittal was a pathway that said if you had a LOCA and the main steam isolation valves failed to close, that that would, in fact, open up a pathway from the containment backwards through the steam line, through the MSIVs, and out into the plant and, thereby, depressurize the containment.

So we added that in, including all of the dependent and common cause failures. And it's a very small contributor, mainly because the LOCA frequencies are relatively small.

I think it reasonably conservative. We applied it to the small LOCAs as well as the medium and larger LOCAs, small LOCA of the steam. If the reactor itself is not depressurized, obviously the pressure can't get back like that.

As far as the post-initiator leak probability, we used a 72-hour mission time. Mission time is the only parameter in my model that deals with the duration of the containment accident pressure. And that was something that the Committee had asked us to look into. How sensitive is it? So I will show you that.

MEMBER SHACK: Your failure rate there is the same as your pre-initiator failure rate.

MR. STUTZKE: That is right.

MEMBER SHACK: Do you want to give us your expert judgment on how much that could elevate?

MR. STUTZKE: Well, that would be hard to say. I can treat it with sensitivity and show you that it is probably a very small contributor like that. But the fact is we don't have good statistical data.

You know, the way we normally collect reliability parameters in PRA would say I have containment that is pressurized. Now, how often does it leak? And we're not in that operating mode very often.

MEMBER SHACK: We don't do that very often.

MR. STUTZKE: So it's a bit problematic to try to get after it. But I understand when the containment is pressurized, it might leak at a higher frequency.

Okay. Here is a new thought, newer than the subcommittee. That is that it had been proposed in some earlier versions of the CAP credit that operator actions might be needed to make that CAP credit effective, notably tripping the drywell coolers.

The current analysis indicates that the actions are not actually needed like that. And so I don't have a model or an event in my model that says, "Operator fails to turn these coolers off."

MEMBER CORRADINI: I don't think I understand. You're saying that some of the calculations that you guys have done by staff are showing that this possible action is not necessary, just by --

MR. STUTZKE: That's correct.

MEMBER CORRADINI: -- just by the thermal hydraulics of the containment --

MR. STUTZKE: Just let them run.

MEMBER CORRADINI: Just let them run? Okay.

MR. STUTZKE: Let me run full bore.

MEMBER SHACK: Now that is not what we got from Browns Ferry.

MR. LOBEL: This is Richard Lobel from the staff.

Actually, the calculations aren't staff calculations. They're Browns Ferry calculations that were submitted at a later time. And what they did was change the value of required NPSH.

And they showed that, even if they kept the fan coolers running, they still had some margin, but it was a decreased margin. It was because they changed the required NPSH value.

MEMBER RAY: Did that suggest they would change the procedures, then, to not call for the securing the cooler?

MR. LOBEL: I believe the plan is to keep the procedure the same for the operator to trip the fan coolers, but if the operator doesn't do that, the calculations show he's still okay.

MEMBER RAY: So any adverse implications of tripping the coolers and then having to restore them at a later time aren't taken into account?

MR. LOBEL: Yes. I have to say, though, that those I think were the last submittals we got from the licensee. And we haven't really formally evaluated that or questioned the licensee on it since we got the submittal.

MEMBER BROWN: How did they get a new NPSH? Was it available or required?

MR. LOBEL: Required.

MEMBER BROWN: Where did they come up with that?

MR. LOBEL: They were using values that they had gotten from their pump vendor that were higher values of required NPSH. And they went to the three percent head drop required NPSH.

So they increased the margin they had by lowering the required NPSH. And that enabled them to show that they didn't need the operator action.

CHAIR ABDEL-KHALIK: The first bullet is not a universal statement, is it?

MR. STUTZKE: No. The bottom line is that it's not in my risk calculation. The second bullet says if you wanted to put it in, we know how to treat it pretty well because human reliability methods would let us make a reasonable estimate of the probability like that.

It would be complicated by the fact that there is a host of other human actions that may be going on at the time. And one normally worries about the dependencies like that.

What I would call your attention to is the third bullet, that it could be a really significant contributor to risk. If you just look at the probabilities that I've shown you before for the pre-initiator, the upon-initiator, and the post-initiator leaks, they're all around 10-6. Okay?

Most post-initiator human reliability numbers are in the range of 10-2, 10-3, could be as low as -4.

MEMBER CORRADINI: So without doing a calculator, you're telling me that it is better to do nothing.

MR. STUTZKE: No. It would be better not to have to rely on an operator action.

MEMBER CORRADINI: Sorry. In this case for that, for an operator action. Excuse me.

MR. STUTZKE: But, you know, if I could speculate a little bit, I mean, one way to remedy it would be to put an automatic trip in the drywell cooler, something like that. There may be hardware cures for this type of issue. So I'm merely pointing out that yes, it could be important.

MEMBER BROWN: The comment was that they

were able to do this because they lowered the required NPSH down to the three percent value. And in your old guidance document, you commented that the field experience was that when you installed the pump, there was a greater uncertainty obtained. In other words, the NPSHr went up due to several effects when they add them all up.

So the three percent value that you get out of factory testing, which is what they used, is not necessarily -- it sounds like they reduced it, but then the actual field experience says that whatever you say you need from factory testing, it's really going to be higher. That's the way I read the guidance.

I'm just responding to the comment as to how they got with conclusion. And it seems to be -- I don't know. There are two conflicting approaches to accepting the three percent. I'm not arguing against it, just it's conflicting based on the construction at this point.

MR. STUTZKE: Understood. So when I roll up all of the contributors from the pre, the upon, and the post-initiator contributors to loss of containment integrity in the internal events model, it is possible to derive this set of curves.

The black one is the composite or the total from all of the contributors. You can see the various contributors. The pre-initiator begins to dominate once you get to about once a week or so. In testing like this, the post tends to be the next highest and then the upon-initiator like that.

If you were to add in, for example, an operator action, this whole curve shifts upwards.

MEMBER BROWN: Which one curves?

MR. STUTZKE: Just relabel the axes.

MEMBER BROWN: How much an order of magnitude?

MR. STUTZKE: It could be one to two orders of magnitude higher.

VICE CHAIR ARMIJO: Oh, wow. Big.

MR. STUTZKE: Operator action drives this thing, I believe.

MEMBER SHACK: Now, I had one other question on this one. Does it include any probability of sump blockage? This is only loss of containment accident pressure due to a loss of containment isolation.

MR. STUTZKE: No. I am not looking at the sump blockage. So okay.

MEMBER CORRADINI: We saw the blockage,

didn't we?

MEMBER SHACK: Well, deterministically, yes, but it's always a probability that you're wrong, right?

MR. STUTZKE: Right.

MEMBER SHACK: How small is that probability?

MEMBER CORRADINI: There is no estimate that I am aware of.

MEMBER SHACK: Just wanted to clarify something.

MR. STUTZKE: Okay. So to return to a question that John had asked before -- well, before I move off of this slide, I will point out the green, yellow, and red bands on the right-hand side correspond to the reg guide 1.174 numerical risk acceptance guidelines.

So anything below 10-6 is considered to be a very small change. Between -6 and -5 is a small change. And above -5 delta-CDF, normally the change wouldn't be approved. So you can begin to see the influence or the importance of frequent containment testing, like that.

I'll confess when we started the model, one of the things I had always been worried about was a trade-off between integrated leak rate extension and credit for containment accident pressure. They seemed to be opposed, and one needs to strike the appropriate balance. I believe the analysis tries to demonstrate that.

MEMBER CORRADINI: But this is not just -- I want to make sure I understood. When you show this testing, this does not have to be integrated cantilever. This is some sort of testing. It gets --

MR. STUTZKE: Some sort of test.

MEMBER CORRADINI: It gets to the leakage level of interest.

MR. STUTZKE: Right.

MEMBER CORRADINI: Okay.

MR. STUTZKE: Certain frequencies.

MEMBER CORRADINI: Okay.

MEMBER SHACK: It isn't going to be an integrated leak test.

MR. STUTZKE: However that is done, but it could be as simple as monitoring nitrogen loss out of containment or nitrogen makeup or it could be done by monitoring oxygen.

I believe the Owners Group will talk to us about that when I get done, about how they could do this. Being a risk theorist, I am allowed to hypothesize and not make it practical sometimes.

Okay. For the seismic risk analysis, we chose to use a simplified method than we are currently using to explore generic issue 199. And it's nothing more than an integration of a mean seismic hazard curve with a mean plant-level fragility curve. It's not a seismic PRA by any shape, stretch, or form of the imagination, but it will give you estimates of the seismic core damage frequency.

I also point out we don't have much more to go to work with. We do have some SPAR models that go into our external events. They're not necessarily the plants of interest to us here. So we did the best we could.

We have new hard rock seismic hazard curves from the U.S. Geological Survey that we are using in here. We are using older EPRI seismic owner group soil amp factors to adjust the hard rock fragility hazards.

The plant-level fragility curves are either coming from IPEEE information or in some cases, I was able to find things in the severe accident mitigation alternatives that were included in the license renewals.

One of the things you have to realize is that about 70 percent of the plants in the country did what are called seismic margins and not seismic PRAs, per se. And so they have never been analyzed with the full extent of seismic risk like this.

There are ways to convert the results of a seismic margins approach into a numerical core damage estimate. And that's what we have chosen to do here.

Now, to that, what we did was to simply add another event in here that said seismically induced loss of containment integrity. It's a little ornate with the plant-level fragility curve and now this.

That assumes, then, that any loss of containment integrity leads directly to core damage. So I have applied it to all of the accident sequences in a sense. And that is not necessarily appropriate. That is conservative.

There are some accident sequences that would evolve and have nothing to do whatsoever with the containment accident pressure credit.

MEMBER BLEY: Where does the fragility number for that come from, Martin? And does it include -- because I know in some plants, the most likely way you would get trouble is the way the piping and the nearby buildings interact so that you might do a tear, something like that.

MR. STUTZKE: Right. Well, right now it is an engineering judgment, the .3 g corresponding to the review-level earthquakes that were used for the IPEEEs like that.

The staff has recently done some work on small leaks out of containment from earthquakes. That came out as a result of the peer review that is being done on the state-of-the-art reactor consequence analysis.

Unfortunately, the work that they did was on Surry. It's not on the Mark 1 containment of Peach Bottom. Okay? So I had nothing other than a gut feel for it. You may realize the actual -- when you look at seismic containment fragilities in risk studies, like NUREG-1150, they're upwards of 1 g or so HCLPF values.

MEMBER BLEY: But there are unusual cases as you --

MR. STUTZKE: There are unusual cases.

MEMBER BLEY: Due to backfill the way piping is connected, --

MR. STUTZKE: Yes.

MEMBER BLEY: -- all sorts of specific things.

MR. STUTZKE: Yes.

MEMBER BLEY: Overall on average, this might be conservative, but I don't have a clue as to how it --

MR. STUTZKE: And I will be honest. I don't either. I can show you sensitivity-wise if I drive the answer up from .3 to .4, it makes all the difference in the world in the results. I mean, it's almost like it's hyper-sensitive to the parameter surprisingly.

When you get below a .3, I mean, most of the plants are coming in at .3 g at the plant-level fragility. So now you've got a competing effect going on. And if the plant-level fragility is much lower, then you don't see the sensitivity like this.

MEMBER BLEY: It doesn't matter.

MEMBER STETKAR: Just out of curiosity because I am looking through backup slides here and I'm a kind of median sort of guy, I'm sure you have it somewhere there. Your median plant-level fragility, median capacity that you used? I mean, you're going to show us results for --

MR. STUTZKE: I will show you results.

MEMBER STETKAR: -- a specific site.

MR. STUTZKE: I don't have -- no, I didn't list all of those numbers for you.

MEMBER STETKAR: Do you have one for --

MR. STUTZKE: Every plant.

MEMBER STETKAR: No. Which one are you going to show us? Are you going to show us numbers here in our table in a minute? Yes.

MEMBER RAY: They are all Mark 1's.

MEMBER STETKAR: Yes, they are all Mark 1's. Was there a large variability among the plant-level fragilities?

MR. STUTZKE: Yes.

MEMBER STETKAR: There was?

MR. STUTZKE: Yes.

MEMBER STETKAR: Give me the range of median capacities, then, out of curiosity.

MR. STUTZKE: I'll have to convert it over.

MEMBER STETKAR: You just have HCLPFs?

MR. STUTZKE: Well, they convert over in the spreadsheet. And I focus on the HCLPFs, not the --

MEMBER STETKAR: Because I convert frequencies to medians.

MR. STUTZKE: I can provide you the information separately.

MEMBER STETKAR: Okay.

MR. STUTZKE: Because the other thing you need to realize is it is not just the HCLPF which is -- let me explain. When you do a seismic fragility, there are two things you need to know. One is the anchor point, the HCLPF at PGA.

And the other is the shape of the expectoral. And they vary all over the place, too, depending on what people assumed.

MEMBER STETKAR: I'm not asking for precision. I'm just sort of asking for sort of a ball park to get a sense of the spread.

MR. STUTZKE: Yes. I mean, at Browns Ferry, what I'm remembering is they're at a .3 or .4 C50 value median capacity.

MEMBER STETKAR: Median capacity, yes.

MR. STUTZKE: But the other thing we have to remember is there have been fixes since IPEEE that are not necessarily --

MEMBER STETKAR: That's fine. I'm just trying to get a feel in general where the median capacity of the plant-level fragility versus your median capacity of the containment versus kind of expected seismic hazard frequencies.

MEMBER BLEY: I'd just throw a caveat out as we have this discussion. If you have ever take the median fragility and the median hazard, you get no chance of breaking.

MEMBER STETKAR: I know that. I am just trying to get --

MEMBER BLEY: In case somebody didn't.

MEMBER STETKAR: I am just trying to get ball park numbers. That's right. They're all in the tails.

MR. STUTZKE: I am glad you raised that point, Dennis, because, as I continue to work on GI-191, I have to remind people seismic risk is an integral quantity.

MEMBER STETKAR: That is right.

MR. STUTZKE: And they always want to pick points off of the curve and multiply them together. I have no intuition for them. It's got to be integrated.

So running through this -- and, of course, I'll be happy to give you all the numbers if you want. So these are all of the Mark 1 plants now with their -- the first table is the estimate of seismic core damage frequency assuming no CAP credit is needed. The middle column is adding in the CAP credit. And then the colored columns are the delta seismic risk.

MEMBER CORRADINI: So just to make sure, the delta between column 3 and column 4, that includes seismic or that is only seismic?

MR. STUTZKE: That is only seismic. You have to add in the internal event on top of this.

MEMBER CORRADINI: Right. Okay. That's what I was trying to get. Okay. Thank you.

MR. STUTZKE: Right.

MEMBER RAY: So, Marty, the seismic is small the way you have calculated it. We expect that. The requirement for CAP credit, which is a conservative assumption, in some cases is an increase of 40 percent, 30 percent, something like that.

MR. STUTZKE: Yes.

MEMBER RAY: If the seismic core damage frequency were higher, would that same relationship exist? I'm just trying to think.

MR. STUTZKE: I don't think so, but it's hard to say because it's not just the function of the plant-level fragility, but it's the specific hazard curve.

MEMBER RAY: Yes.

MR. STUTZKE: And, by the way, these are not just integrated on PGA. They're integrated across a variety of spectral frequencies, too. And --

MEMBER BLEY: Right, right. Yes. I didn't think you could answer that question, but --

MR. STUTZKE: Yes.

MEMBER BLEY: You know, because we're starting here with a low probability and then you ask the question, what is the effect of the change, obviously the effect is going to be -- I shouldn't say "obviously." The effect is small, and that makes sense.

MR. STUTZKE: Yes.

MEMBER BLEY: But I'm not sure that gets me where I need to go.

MEMBER RAY: You have all of these plants. Change is on a small number, which are going to be small. But the real question is significance of the CAP credit.

MR. STUTZKE: Right.

MEMBER POWERS: In that regard, I just can't help but comment. You have indicated that these deltas meet the acceptance risk guidelines, but there are lots of criteria that precede that that may or may not be acceptable.

MR. STUTZKE: Yes. That's right.

MEMBER POWERS: It's all about defense-in-depth. Containment is sacred.

MR. STUTZKE: Well, the other thing I would also point out is that, of course, I have no parametric uncertainty on any of these numbers. And then, quite frankly, it's hard to do, but the USGS has not yet published their fractile estimates of their hazard curves.

So I can't even get started on a problem like that. But, I mean, these numbers could be plus or minus an order of magnitude with the uncertainty bound.

MEMBER POWERS: Pretty easily.

MR. STUTZKE: Easily. So, I mean, it is what it is.

MEMBER RAY: Thank you.

MEMBER SHACK: Now, you left out our old fried fire yet because that is treated deterministically.

MEMBER RAY: He is going to get to it, I think.

MR. STUTZKE: I said early on we hadn't treated the fire because we don't have the cable-routing information that would let us make a reasonable -- that is the only one that is working out there right now.

MEMBER BLEY: Before you talk about that

some more, the seismics there, what you're doing in all of the PRA work is illustrating a way to do these calculations, not claiming that we have got them for all of these plants, yes or no?

MR. STUTZKE: Well, I think we have a pretty good handle on it for all the Mark 1 containment. Like this, we have not done anything for the other types of plants that may resolve or require containment accident pressure credit.

So yes, it's an approach and a demonstration for the immediate plants of concern. But the risk seems to be small.

Okay. Qualitatively in the internal events model, there is only one cut set where the loss of containment integrity goes straight to core damage. And that is the large LOCA. Everything else has other failures, other hardware failures, software failures, or things like that, which points out that is an important consideration of defense-in-depth, indicators like that.

Of course, the two bullets, we've just gotten done talking about that it appears that the increase in risk is small and meets the guidance in 1.174.

Contributors: The pre-initiator seems to be name of the game followed up by the post and the upon-initiator. And, of course, these are just the internal event types of numbers like this.

If you look at the comparison of this result with the pretty graph and just look at the numerical values, you will see the seismic risk is larger than the internal event risk, which is not necessarily surprising given the way that I calculated it.

MEMBER CORRADINI: I guess that is a good point, Marty, I mean, really.

MR. STUTZKE: Okay. The other thing, the other way to decide whether something is of interest to us, it meets the criteria for significant basic event defined in the PRA standards. So that's telling you Fussell-Vesely importance measures above 005 or the RAW values above 2.

And you can see. I mean, loss of containment integrity is a significant even. I mean, it's really significant. And what is interesting is it doesn't matter much what model parameters I put in. It is importance measures springing, which you would expect.

The major sensitivities to this are, of course, the containment leak failure rate and the surveillance test interval like this.

This is a breakdown showing you the contributors by initiating event. You'll see, as the Committee had asked, we had done the LOCAs as well as all the transients, all the other internal events like this. And you don't get a big change.

MEMBER CORRADINI: I guess I don't -- can you go back a slide? Maybe you said it and I didn't -- one more. I'm sorry. Your first bullet on this slide and then going to your table, I guess maybe I've missed it. Is it because it directly results in core damage, even though it is a small contributor to the CDF? I want to make sure I get it right.

MR. STUTZKE: That's right. Qualitatively what it says is if you have a large LOCA and a loss of containment integrity, you are going to core damage. What the table over here says is that is not very likely because the frequency of large-break LOCAs is not very likely as compared to some of the other transients here; for example, loss of off-site power, these sorts of things.

MEMBER CORRADINI: And that is not a new observation. That is just an observation that has already been known about Mark 1's?

MR. STUTZKE: Just in general, the

relative contributors or frequencies of initiating events.

MEMBER CORRADINI: Right. But I guess what I am getting at is -- okay.

MEMBER SHACK: Are these LOCA frequencies based on essentially the expert elicitation or is this older data?

MR. STUTZKE: This is older data. It's what we normally use in our store model.

MEMBER SHACK: The conventional?

MR. STUTZKE: Right.

MEMBER RAY: Because this says internal events, though, it excludes seismic.

MR. STUTZKE: That is correct.

MEMBER RAY: Oh, okay.

MEMBER CORRADINI: Would seismic change the ordering, though? I wouldn't think it would.

MEMBER SIEBER: It depends on where the plant is.

MEMBER CORRADINI: Oh, true.

MR. STUTZKE: It could change all over. These are not necessarily -- I mean, they're not sorted from high to low contributors.

MEMBER CORRADINI: No. I understand that. But I'm just looking at the thing that dominates this loss-of-off-site power. Would seismic make one of the others overwhelm that? That's what I guess I was doing.

MR. STUTZKE: Yes, possibly. I mean, what the seismic says to me is most likely what happens in an earthquake is you lose loss-of-off-site power. Okay? And that's putting you down the road to station blackout.

So with some other failures, then they don't need to be seismically induced. They could be random diesel failures, common cause. Okay? And that's a reasonably likely scenario. And then if the containment gets shaken hard enough to make a hole of the right size, you're in trouble. That's the effect.

So it's not necessarily when you think about the seismic risk that the earthquake is so large that it creates a large-break LOCA in the system, but somehow all ECCS pumps survive. And now there is a hole in the containment.

MEMBER CORRADINI: Right, right.

MR. STUTZKE: I would say that's pretty improbable.

MEMBER CORRADINI: I guess your story leaves it -- the way you just laid out the possibility leads me to think that still the loss of off-site power would be the first thing a seismic event would initiate.

MR. STUTZKE: Yes. That is almost a slam dunk for earthquakes. I mean, in a seismic margins approach, you just assume you have a LOOP going in. Switchyards don't react well to earthquakes.

MEMBER SIEBER: Now, you didn't do an external event ones, like fires and floods?

MR. STUTZKE: No, I haven't picked up the external floods or the fires.

MEMBER SIEBER: Do you think that is going to affect your conclusion in a big way?

MR. STUTZKE: The one that personally bothers me is fire.

MEMBER SIEBER: Fire.

MEMBER BLEY: Are you planning anything to look at fire?

MR. STUTZKE: Well, in order to attack that, I am going to have to wait. We developed our SPAR external event models. And they are kind of on hold now until NFPA 805 gets implemented and we can see the PRAs coming out and may be aware that there are methodological issues but doing fire PRAs.

So we don't have plans to augment our current SPAR models any time in the future, certainly not on the timeline that would help you guys.

MEMBER SIEBER: Do you think it would be sort of chancey to go forward with a CAP credit when you don't know what the external event option would be?

MR. STUTZKE: Well, with respect to fire, you know, there are deterministic ways to treat it. That's what we tend to rely upon here.

Okay. So, to wrap up real quick -- I see I am already behind schedule. We perhaps come to the hard slides. No, I won't take you through Marty's matrix algebra like that, but what we know right now is for the quantified risk, it is that they do seem to be consistent with the guidance in reg guide 1.174 with all the caveats in there.

And the fire risk is a notable question mark sitting out in the analysis. I think the seismic risk the way I estimated it is probably high. It's more likely that it's high than it is an underestimate, I think, across the --

MEMBER POWERS: Let me ask you a question about that. When you calculate the seismic risk, you do not consider seismically induced fires?

MR. STUTZKE: That is correct.

MEMBER POWERS: But we know that, for

instance, in recent Japanese earthquakes, one of the things that seismic events do is they induce fires.

MR. STUTZKE: Right. The way to answer that is that when you look at this list of plants, we're taking what we got out of the IPEEE. In some cases, if they had a good seismic PRA behind it, there will be seismic fires in principle in that model will be treated.

MEMBER POWERS: Do any of the seismic models actually have seismically induced fires in them?

MR. STUTZKE: I thought there were a few plants that did but maybe. I mean, it's out there. It's something that needs to be done.

MEMBER POWERS: I don't think you can say that your seismic risk is ipso facto conservative. You may have looked at the mechanical damage conservatively, but what we're learning about fires is ancillary things are non-trivial.

MEMBER STETKAR: Traditionally, at least in my experience, what people have done is they have not quantified it explicitly. They have typically looked at the seismic contributors where you're getting high seismic contribution to core damage. Usually you have enough equipment fail that it doesn't make too much difference whether or not you also burn it.

So there's probably a median range where you might be vulnerable to seismically induced failures that would give you a fire but not yet fail enough equipment seismically where you get a --

MEMBER POWERS: And that gets numerous.

MEMBER STETKAR: A lot of combinations. And people have traditionally not looked at that.

MEMBER POWERS: Yes. And, I mean, I think we intuitively always knew that seismic events could induce fires, but we have gotten a particularly dramatic example at hand now.

MEMBER RAY: I think the Japanese experience -- Marty has already mentioned it -- can also lead us to understand that the hazard curve is not necessarily highly conservative.

MEMBER POWERS: I would be careful because the Japanese construction was different.

MEMBER RAY: No. I'm talking about the seismology disconnected from the plant.

MEMBER POWERS: I don't know that you can conclude that readily because the pre-event seismography of the site may not have been as detailed as people would like.

MEMBER RAY: Well, that is precisely my point.

MR. HARRISON: This is Donnie Harrison from the NRR, Division of Risk Assessment. From the work I have done in the pst and the observations following most earthquakes, the seismic-induced fires are typically in your large transformers, typically. You will break the ceramic insulators, and they will have oil spills that ignite. That was the Japanese experience. That is also the experience of other events similar to that.

I will point out one of the main contributors of a seismic event typically is a loss of off-site power as well. So if you are losing your large transformers as a result of the earthquake, you are also gaining a loss of off-site power anyway.

So in that sense, they are typically redundant. It may be impressive as a view to see it, but the net result typically is the same typically. There can be exceptions.

MEMBER POWERS: In these particular plants that we are looking at here, if we lose off-site power, we are going to go to emergency power or to batteries, right?

MR. HARRISON: Right, right. You will

typically -- even with the transformer fire, you will just lose the off-site grid. You will still be able to power from your diesel generators.

MEMBER POWERS: But if we have a fire going on, we are going to have spurious actuations and all kinds of things.

MR. HARRISON: Well, no, no. The fire is out on the transformer on the switchyard.

MEMBER POWERS: I see what you're saying.

MR. HARRISON: Typically that is where it's at. So you're not getting cable fires that would give you the MSOs, the multiple spurious operations.

So, again, that's typically what you'll see is that type of event. So you lose off-site power assuming -- that usually occurs at a much lower level. You will have a HCLPF around .1, a median seismic fragility around .2 g. So that occurs at a much lower level than what Marty is doing here, using a HCLPF of .3.

So almost, if you will, you expect in a large earthquake to lose the power from the switchyard. And so you're relying on your diesels to avoid the blackout event.

MEMBER STETKAR: I think the things people have not looked at, though -- and I agree with you, Donnie, except other sources of fires, there's a lot of hydrogen in turbine buildings, for example, more in this plant than in other plants. On the other hand, the general seismic capacity of the stuff in the turbine building is also pretty low.

So the question is, well, if you failed equipment physically in the turbine building and then initiated a fire, can you initiate other types of spurious signals that Dana mentioned? And do you have things like hydrogen lines, which are the things I would worry about, routed through parts of the plant that you haven't thought about? And that's the kind of thing that we worry about. And those are the kinds of things that people typically have not looked at as closely out in auxiliary buildings or reactor buildings or those kinds of areas.

MR. HARRISON: I agree. That would definitely be an area where as we go forward on seismically induced fires, it's something to look at.

Just, like I said, from my experience, the main event is when you get a fire, it's usually the large transformers that ignite.

MR. STUTZKE: Let's move over to the second set of viewgraphs here on the application of the risk insights. Some of this material is again repeated from the subcommittee, and some of it is new, where we were trying to answer some of your questions. I don't think we have this.

CHAIR ABDEL-KHALIK: Do we have this presentation?

MEMBER SHACK: We have it electronically.

MR. STUTZKE: It didn't get on the back of the other one.

MEMBER SHACK: It doesn't look like it got on the back of the other one.

CHAIR ABDEL-KHALIK: Does the staff have hard copies of this presentation?

MEMBER SHACK: Why don't you just continue on, Marty.

MR. STUTZKE: Okay. So again, a recap of the risk insights is that what we have quantified so far looks like it meets the risk acceptance guidelines like this. Of course, we have no fire results at all like this.

I wanted to provide you with a road map and a little perspective on how one looks at this in regulatory space for extended power uprate submitted as non-risk-informed license amendment request. And so they were reviewed under standard review plan section 19.2, appendix D.

That basically says one way to confirm -- let me back up. What that appendix requires is that when you look at non-risk-informed license amendments, PRA is used to decide whether it rebuts the presumption of adequate protection that a plant would achieve if it meets the applicable regulations and license conditions and things.

So the numerical guidelines in reg guide 1.174 don't necessarily apply. They're not the limits that they are in risk-informed license amendments. But, rather, the role of the PRA is to try to get at adequate protection like this.

And that thinking is what I am trying to illustrate here on the chain. It started out with SECY-99-246 all the way down into its incarnation into the standard review plan.

This is a rather unusual piece of the standard review plan when you think about it because it has actually been reviewed by the Commission. Other parts of our plan haven't received that level of review. The message here is that we're trying to get adequate protection and not just small risk results like that.

One way to go after adequate protection that is listed in there, the SRP 19.2, appendix D, is that it says you should consider the five key principles of risk-informed decision-making that are in reg guide 1.174.

And the principles are here. You meet the regulations. You are consistent with the defense-in-depth philosophy. You maintain sufficient safety margin, small risk increases and performance measurement strategies.

And I think when we come to the issue of containment accident pressure credit, the problem here is what we struggle with is what is the appropriate balance among all of these principles? Because we know that when we credit containment accident pressure, we have introduced a dependency between the containment barrier and the clad barrier. So we understand that we are weakening the plant's defense-in-depth posture. And that's, of course, something that we don't necessarily want to do, but it's offset by the fact that the risk increase seems to be small like this than on the deterministic side, where they have looked at safety margins and their calculations and things like that.

So the problem here is, how does one achieve the appropriate balance among these principles when applying them to specific plant licensing sorts of decisions here?

So the Commission defined defense-in-depth as the notion that safety is not wholly dependent on any single element of the design, construction, maintenance, or operation. It is a broader philosophy than just a simple barrier concept like this but more considering the totality of things that we do as regulators and plants do as a result of that to achieve the defense-in-depth necessary.

The Commission in its white paper indicated that decisions on adequacy or a necessity for defense-in-depth should reflect risk insights. So they're opening the door for conceding that a trade-off between defense-in-depth posture and risk results is appropriate.

MEMBER RAY: I guess I would say at this point there must be an implicit belief when we say that we have an appropriate level of confidence in the risk insights.

MR. STUTZKE: We are getting to that. But you're right because that is something that this Committee has been extremely interested in for the last ten years.

I have mentioned that the subcommittee, this letter that the ACRS had written in 1999. It's a letter that Dr. Powers signed on the role of defense-in-depth and risk-informed regulation. This is the famous structuralist/rationalist approach to defense-in-depth like this. I am pointing it out because it indicates this idea of a trade-off between defense-in-depth and them.

The other thing the letter dwells is how certain or uncertain are you in your risk results because defense-in-depth should be applied to compensate for the uncertainty or the incompleteness of the risk results.

And already within the last hour, we have identified -- well, we haven't quantified seismic fire or any fires at all where aircraft crashed or all these other sorts of things like that. So we have these uncertainties.

To make it even worse, there are issues in modeling that we go on, the issues of what are called the unknown unknowns. What if you're wrong? What did you forget? What is not in the model like that?

And that is enunciated in a letter, joint letter, between the ACNW and the ACRS, again signed not only by Dr. Powers but Dr. Garrick. And it says, well, okay. Defense-in-depth is a strategy to ensure safety given unquantified uncertainty in PRA. Here you see it laid out like that. And the amount and extent of compensatory measures should depend on your degree of uncertainty and how much risk it proposes.

So that's high-level principles like this about now we understand how to begin to make the trade-off, but it concludes okay. This is ultimately a judgment value. How do you do this?

And part of the result of that is that the staff at the Commission's direction had been invited to consider whether we wanted to add a statement on defense-in-depth to the PRA policy statement. Okay?

A workshop was held. And the staff recommended no. We need a separate statement on defense-in-depth. More time went by. And my current understanding of that issue is we will consider developing a policy statement on defense-in-depth for new plants after NGNP is licensed. So this whole effort is kind of --

MEMBER CORRADINI: Why then?

MR. STUTZKE: We need the insights of how to do it.

MEMBER CORRADINI: Really?

MR. STUTZKE: But it is interesting that, first of all, it is focused on new and advanced plants, not the current plants.

MEMBER CORRADINI: And we are going to wait for something we know even less about to clarify. Is that what you just said to me?

MR. STUTZKE: Yes, that is the current. But I don't work in new reactors anymore. And I don't understand the evolution of how they got here.

But I think you begin to appreciate the problem that staff reviewers have. And it's like, gee, we are supposed to make these trade-offs. And how do we do it?

MEMBER POWERS: That's why you get the big bucks.

MR. STUTZKE: Whatever we do you guys are going to disagree with.

MEMBER BLEY: Just to calibrate, how long ago was that workshop?

MEMBER SIEBER: They haven't done it yet.

MR. STUTZKE: A couple of years. So we do actually have guidance. I don't want to say we are in a black hole here. We do have guidance in reg guide 1.174. And it talks about consistency with defense-in-depth. It's the following seven items here. And I flagged the one that seems to come up in containment accident pressure. The independence of barriers has, in fact, been degraded like this.

Now, to make it even more confusing, here is what the standard review plan says about defense-in-depth. It says do all of these and temper your review with these considerations.

So the change does not result in a significant increase to the existing challenges, significant change of the failure, new dependencies that significantly increase. And then the obvious question is, what is significant here? And I can't answer that.

MEMBER POWERS: Well, I think that, in drafting at least one of the letters that you have cited here, the authors, the debaters might well have considered ten percent as significant. They would not resist the idea that ten percent was significant.

MEMBER RAY: Marty, there is not anything here -- or if there is, it went past me too fast -- indicating what the motivation for the change needs to be in order to entertain this kind of trade-off that you're doing such a good job of explaining to us sincerely.

Has there ever been anything that said this is for use in the following circumstances only?

MR. STUTZKE: Not that I know of. We don't dwell on why licensees build power plants. Our goal is to make certain that whatever is built is safe.

MEMBER RAY: I understand that, but you do talk about trade-offs. And usually in other circumstances I am familiar with, trade-offs are motivated by some reason other than just "I asked for it. So do it." Okay. Thank you.

MR. STUTZKE: Okay. So I do have one other thing that I wanted to share with you here. We had seen this slide before at the subcommittee. We're not changing programmatic elements that affect defense-in-depth. We're not changing inspections or how things work.

The staff guidance does consider the thermal hydraulic uncertainties and available and required. We have this notion coming out of the PRA now about adequate containment integrity monitoring, like that.

The notion of the size of the hole you need to cavitate the pumps is smaller than the size of the hole you need to cause a large early release. So we have some balance between accident prevention and accident mitigation.

MEMBER CORRADINI: How do we have that? Say that again.

MR. STUTZKE: Because not every core damage accident that occurs due to a failure of the CAP credit will automatically be a large early release. The hole size is just too small, not necessarily. I mean, there is a possibility of containment isolation fails, then it's eventually a large early release.

MEMBER CORRADINI: I was just looking at your numbers. It's 20 given compared to 100.

MR. STUTZKE: Right. LERF is normally defined at about 100 La. There are different numbers.

MEMBER POWERS: But for this realm, would large early release be the appropriate metric here or should it be 10 CFR Part 100?

MEMBER CORRADINI: Then it would be much lower than 100.

MEMBER POWERS: Yes. Two La would probably get you in trouble, maybe 10 La get you in --

MEMBER CORRADINI: I was thinking it was the same as 10 to 20.

MEMBER RAY: Yes. I think that's right.

MEMBER BROWN: Say that again, Dana.

MEMBER POWERS: Well, I mean, it seems to me we are working in design basis space here. And so the controlling thing is not LERF but 10 CFR Part 100.

And I think you get in trouble there. Certainly 10 La you would get in trouble with that requirement. That's 25 rem during the worst 2 hours of the accident site boundary, 5 rem in the control room.

MR. STUTZKE: Okay. The last part is we had had a discussion with the subcommittee before about the meaning and the intent of practicably altered. Yes, we did. See?

MEMBER SIEBER: Yes.

MR. STUTZKE: We actually listened to you guys. The proposed staff guidance says licensee shall justify the use of containment accident pressure as necessary because the plant may not be practicably altered, like this.

We went back from the subcommittee and realized at the time with the risk results we had being only the internal events and the very small delta-CDFs that this guidance was probably moot because you would never be able to justify it as a cost-beneficial sort of modification.

When we went back and we added in the seismic risk, the seismic risk is larger. You know, I have trouble with my grammar here. If I say it's a significant contributor, that means something in accordance with the Code. And I'm not allowed to use the word "dominant" anymore.

(Laughter.)

MR. STUTZKE: I'm running out of adjectives here.

MEMBER SIEBER: Switch to a different language.

MR. STUTZKE: I used the word "major" here and apparently gave Mr. Dennig over here a heart attack last night.

(Laughter.)

MR. STUTZKE: It's like okay. But what I mean to say is it looks like the external event risks are higher than the internal event risk.

MEMBER SIEBER: Yes.

MR. STUTZKE: Like that, understand. And, of course, they're going to depend on the hazard curves and the fragility as well as all the assumptions and things like that.

So I went back and over the last couple of days looked at regulatory analysis guidelines for doing value impact studies. And they're in NUREG/BR-0184. These are the guidelines that the staff would use to impose or to justify backfits on licensees.

MEMBER BROWN: So if it costs more than 75k, it's not justified to make a change. You just go with the credit. That's chicken feed.

MEMBER SIEBER: That is your Xerox bill for a month.

MR. STUTZKE: The joke in the Office of Research when this result was produced to us, you can't paint the men's room for this kind of money in a nuclear power plant. Okay.

Now, this is at -6. And some of the numbers I showed you before with the seismic contributors were higher than that by an order of magnitude.

CHAIR ABDEL-KHALIK: Would you consider the backfit if it is done as a part of a power uprate?

MR. STUTZKE: No. I'm trying to use the backfit guidelines to show you. I'm working the problem the other way around.

MEMBER SIEBER: How much can I spend for the risk?

MR. STUTZKE: What should a licensee spend in order to avoid using the --

MEMBER POWERS: I understand this question of adequate protection. It won't be decided on this basis.

MEMBER RAY: I got lots of other things, by the way, that I want to advance as changes because it wouldn't cost more than that criteria. In other words, there's a whole truckload of things to satisfy that requirement.

MEMBER SIEBER: A small truck.

MR. STUTZKE: I did check this number against the SAMA that we used at Browns Ferry and at Monticello.

MR. DENNIG: Marty, could you say something about the SRP 19.2 and the threshold for taking a non-risk-informed submittal --

MR. STUTZKE: Yes.

MR. DENNIG: -- and probing it and holding it accountable for risk analysis?

MR. STUTZKE: Right. Okay. Once a non-risk-informed license member comes in and it's decided that it has some risk implications, then the staff would make its investigation. The burden is placed on the staff to consider these things.

And if that license amendment were to be rejected on the basis of the risk results, that would be elevated up to basically the office director, who would then have to consider whether he would notify the Commission.

MEMBER CORRADINI: Can you say that again? I'm sorry. Can you just repeat that?

MR. STUTZKE: In order to reject a non-risk-informed license amendment on the basis of risk, it has to be reviewed by the appropriate authority. And it's a much higher level of authority than we normally do.

When the guys at NRR review a license amendment and the branch chief agrees with it, that's basically it. It's done. If we were to reject a licensee's non-risk-informed amendment on the basis of these sorts of PRA arguments here, that's at least a division director's level review that would probably be escalated to the office director's and considered for becoming a candidate for a SECY paper to the Commission.

MEMBER RAY: Well, supposing it's rejected because it violates the --

MEMBER CORRADINI: Independence of barriers?

MEMBER RAY: The independence of barriers, period. In other words, it's a question of who is the burden on. And that independence of barriers is not degraded seems like a fairly simple and straightforward thing, which you would then have to justify not --

MR. STUTZKE: Right, but that criteria, the independence of barriers not being degraded, is coming from reg guide 1.174, which is the risk-informed license amendment.

MEMBER RAY: It is. That's correct. But my point is that you can appeal to that requirement as being a reason why something isn't approved.

MR. STUTZKE: Right.

MEMBER SIEBER: Isn't there some --

MR. STUTZKE: No. Even that would be elevated up.

MEMBER RAY: Well, all right.

MR. STUTZKE: Because it is the PRA people saying, "Wait a minute. We have a big problem here because one of our principles has not been satisfied."

MEMBER CORRADINI: But can I just make sure I understand that? Then to reject it, you would have to say back to your green, yellow, and pink "It's approaching into the pink region."

MR. STUTZKE: Or any one of the other principles. So in this case for CAP credit, we could argue, "Okay. The barriers have been degraded. And that gives us concern. It's one of our principles." But it seems to be offset to some extent by small risk numbers.

MEMBER RAY: Well, only as calculated in a particular way, which is then subject to all kinds of debate.

MR. STUTZKE: Yes.

MEMBER SIEBER: I thought there were some plants that for their normal license required some kind of CAP credit, like the old sub-atmospheric PWRs. I mean, they started from day one with a CAP credit, which means that they never had independent barriers the way we're thinking about them now.

So if you went to a courtroom to prove a case, I think that that would be the argument against granting some kind of CAP credit.

MR. DENNIG: Marty?

MEMBER SIEBER: And I think there are some Mark 1's in the same position, right?

MR. DENNIG: Correct me if I'm wrong. We have gotten input from the risk experts from both NRR and Research. And it is my understanding that the judgment is that this particular issue would not qualify as a special circumstance. It wouldn't make that threshold. So we wouldn't go down that path.

MR. HARRISON: I will answer Bob's question. It's again Donnie Harrison from NRR/DRA.

Marty has given you the simplified view of how appendix D actually works. The first step in the process if the staff in reviewing a non-risk-informed submittal believes there is a concern about adequate protection, this is not a concern about meeting the risk metrics, it's a concern about adequate protection, they then raise that to their management, expressing what that concern is.

Management at that point then can provide a resolution path or investigate further to go after risk information, additional defense-in-depth information, compensatory measures. And all that does is empower the staff at that point to then go back to the licensee to request that type of information.

Once you go back to the licensee with a request for the information, if the licensee provides the information, you can evaluate it and make a determination. If a licensee does not provide you that information, the staff has to make an argument one way or another as to if the risks are acceptable, defense-in-depth is acceptable or not, and make that recommendation to management, who will then make a final decision. And it all gets documented and processed.

So it's a much more complicated process

with many hoops which the staff has to go through to make a determination. And recognize we're talking adequate protection.

A plant that comes in with a number that says it's as high as 10-4, that still meets adequate protection from our mindset. So it can be extremely high numbers in core damage frequency and still be considered adequate. So we're not talking about changes of 10-6 delta. We're talking about a net of 10-4.

MEMBER CORRADINI: But just for the sake of my understanding, then it goes back to where Marty had his color-coded bands. It's got to enter into a band that's a big significant --

MR. HARRISON: You are already in region I for us to challenge adequate protection. And you are not just barely into region I. You are well into region I.

MEMBER CORRADINI: Okay. Thank you.

MEMBER SHACK: We are running a little bit behind, gentlemen.

MR. STUTZKE: I am concluded.

MEMBER SIEBER: That was a great presentation, I thought.

MEMBER SHACK: Our next presenter will be

Mr. Alan Wojchouski from the BWR CAP Committee.

MR. WOJCHOUSKI: Good afternoon. My name is Alan Wojchouski. I am the Chairman of the BWR Owners Group Containment Accident Pressure Committee.

I am here to talk today about monitoring containment integrity that kind of falls into the last presentation you had on risk-informed with the pre-initiator leak probability.

Two other topics that I plan on covering briefly happen to be to give a response in licensing space if you had DBA LOCA and loss-of-containment accident pressure, would you really need containment accident overpressure to accommodate that? We talked about that briefly last time in the subcommittee.

The last thing that I would like to cover is a defense-in-depth type of consideration. It's not as detailed as you have already heard. It's kind of a simplified approach on it, but I'll just draw that out also.

I also prepared this presentation to start off with the three summary points to start with so that you get an idea of where I am finally going. And then I have subsequent slides to go over each one of those different points so that you can see where that was built.

At the very end, I have the same summary points again. So if I hadn't covered it previously, please go ahead and ask questions on that last summary page. And I'll catch up with it.

Summary. The first bullet, what I broke this down into is basically talking about the monitoring and the containment integrity. So I am going to be going over tech specs and operator --

MEMBER RYAN: Could you just not rap the microphone with your papers? Don't do that.

MR. WOJCHOUSKI: Thank you. I should have learned from Marty's.

-- tech specs and operator monitoring that would detect a loss of containment integrity that affects the NPSH margin. Also I will be talking about the tech specs, what we have currently existing and what they require for prompt actions.

The second idea or bullet is going to be the realistic analysis shows that for loss of containment integrity with a DBA LOCA, credit for containment accident pressure is not needed. I will go into a lot of detail on that. I have that one slide that we went over previously in the subcommittee on that.

The last one is going to be, like I said before, defense-in-depth type of considerations. For design basis and beyond design basis events, loss of primary containment defense barrier can be mitigated prior to loss of the fuel defense barrier. Operator actions to mitigate loss of the containment integrity can be taken to assure adequate NPSHa for the ECCS pumps and core cooling.

So I'll be going through -- each one of these has a different slide for it to explain how did I come to those conclusions and why am I presenting that?

Containment integrity. Programs exist that are at the sites right now that assure containment leakage does not approach the level needed to lose your NPSH margin. The containment design itself is originally set up so that you maintain that barrier and its integrity.

The main programs that we have at the operating license requirements that assure integrity will be maintained are -- we have the primary containment isolation system, which its basic design is redundant containment isolation valves.

It also has containment isolation signals, which we'll go ahead and give you different groups, isolations on it. And included in that is different procedures in which you will verify your valve alignments, as verified periodically.

Typically when you start up, all the valves within the plant are walked down, verifying that they're in the correct position. There are tech specs on every 30 days going over ECCS valve positions to verify their positions also. So that's out there.

The second one that goes ahead and monitors for containment integrity is the appendix J test program. This goes ahead and during a refueling outage leak test, your primary containment isolation valves, your double gasket seals, your bellows on your penetrations.

You go ahead and do an assessment of your leakage of your containment. It also goes ahead periodically, does an integrated leak rate test, in which you take the whole containment, pressurize it up to greater than your Pa, and do a leak test of the whole containment.

Next one that I'll cover is containment boundary in-service inspection program. Out of ASME IWE sections, the licensees are required to go over their containments. They have qualified inspectors that write up reports on each one of the different components within the containment.

The next one I'll be talking about is the operational containment leakage monitoring. This has several different components to it: the drywell pressure, the nitrogen makeup, and the oxygen concentration. I'll be covering that on a different slide.

I will also be going over the technical specifications required for the prompt shutdown if containment integrity is lost during operations.

So the reason why I'm putting the tech specs in there is Marty had gone over and had a proposed different set of tech specs that it was using for his probability. I'll show you what some of our existing tech specs are and how they could dovetail into that.

MEMBER BROWN: The table didn't show prompt. I don't remember the matrix. Was it like 24 hours?

MR. WOJCHOUSKI: Well, it depends. It is a subject. Your answer is right here.

MEMBER BROWN: Okay. I'll turn the page.

MR. WOJCHOUSKI: Right here. For the appendix J program, it requires you testing the different leakage paths at each refueling outage. And what it has is that if you exceed a leakage rate of

1.0 La, you have lost your primary containment integrity.

If you lose primary containment integrity, this is a tech spec. This is a Monticello-specific tech spec. This is similar for the standard tech specs and improved standard tech specs. So all the other BWRs that have those tech specs should be very similar. If not, if they have custom tech specs, it is going to be all the same.

What it says is that you have to have primary containment, need to be operable during all modes of operation, modes 1, 2, and 3. During 4, that is shutdown. You don't need primary containment for that.

If you lose primary containment, you have one hour to restore it. If you cannot get it restored within the one hour, you have 12 hours to be in hot shutdown and 36 hours to be in cold shutdown. So this means that you have to move rather quickly if you find a leakage greater than one La. This is a lot less than the 20 that Marty was using or 40 La that we had considered and mentioned earlier for the loss of your margin in NPSHa. So this exists.

Operational containment leakage monitoring for preexisting leaks. We're looking for gross leaking in which would be sufficient magnitude to affect the NPSH margin. You can monitor it currently by: drywell pressure, our Mark 1 containments, our positive pressure. They are usually about a half a psi.

I mentioned before that Monticello has between .1 and 1.5. That's a normal operating margin. If you're outside those bands, we have an annunciator at the control room that will alert the operators that you've got something going on, either a leak inside containment, like an air leak that's pressurizing in it to get you above the one and a half or if you have a breach of containment and you're less than .1 pounds, that same alarm will go off to notify you of that. It's probably the quickest response you'll find if you have a major breach in your containment.

The second one happens to be that I mention here is the containment oxygen concentration. I will cover that in a little bit more detail. And the last one I've talked about is the nitrogen consumption, the nitrogen makeup system. I will cover that also on the very next slide.

I covered part of this already, but what it is, it's for the drywell pressure drops out of the bands. You hit the alarms. For the nitrogen makeup system I mentioned last time at the subcommittee that Monticello really doesn't use their nitrogen makeup system. We have enough small tight enough containment that's small leakage out of our instrument air, which is nitrogen, takes care of keeping it pressurized.

And how we get pressure out of it is we have a continuous air monitoring system in which we can either have this discharge back into the torus, which is back inside containment, or can put it off to the reactor building plenum that discharges that off of the site.

We have the system on nitrogen makeup system at Monticello. We haven't used it in a long time. We don't really use that to monitor containment gross leakage because it is so small.

MEMBER SHACK: Does gross leakage here mean 20 La or greater than 1 La?

MR. WOJCHOUSKI: Gross leakage for Monticello's nitrogen makeup capacity maximum is 2 standard cubic feet per minute, which is like 120 standard cubic feet per hour. Monticello La is 458 standard cubic feet per hour. So it is a fraction of --

MEMBER BROWN: That's 25 percent, then, roughly.

MR. WOJCHOUSKI: Roughly. Going on to Browns Ferry, I asked them the same kind of question. They have the nitrogen makeup system. Their max capacity is 50 percent of the La. So if they maxxed out their nitrogen makeup system, it's less than their La. So that is one way of monitoring the gross leakage. And that's a lot less than the 20 or 40 that we're talking about. So I think you'll find it there.

The last one I have on this slide happens to be the containment oxygen concentration. Our tech specs require us to maintain primary containment oxygen concentration less than four percent by volume.

That is measured on a weekly basis. You go in and turn on an analyzer, take a sample off of a drywell, take a sample off of our torus, meet the tech spec requirements, which says you got the sample once per week. If you remember, Marty was modeling his off of this oxygen one. It had a surveillance of once a week. So this is what we do.

If you went ahead and had a large leak, which would go ahead and cause the loss of your margin in NPSH, your oxygen concentration would start to rise within the containment. And you will be able to see it on this measurement.

The ones that are much more sensitive, the drywell pressure, you will see it much sooner on that or if you have a nitrogen makeup system, you will see that much sooner than those. It will be a very fast response.

On both of these, what happens is if you get the alarms, stop, confirm what is going on, you will initiate an investigation for the CAP action process. As soon as they figure out what is going on here, they will find out if they're greater than 1 La or not. If they are greater than 1 La, they're into the tech spec, which requires them to restore containment integrity or be shut down.

So if you are looking back at what was talked about in the last presentation on the pre-probability, the pre-initiation pre-probability, in which he said if it was continuous, it's very small. If it's once a week, it's larger. If it's 15 years, it goes huge.

If you look at what we actually do right now, especially with the pressure in the nitrogen makeup, it's almost a continuous monitoring system. So that would tend you to drive it towards the lower probabilities. So that is what I wanted you to get out of this one and how it ties into Marty's presentation.

Second item that I brought up is a question that had been asked by the ACRS and others that typically utilities come in and they're asking for containment overpressure. And people say, "You're asking for all of this overpressure. What do you really need?"

And people say, "Well, it's done deterministically. You're at your top bounding values." River temperature is max. You take decay heat. It takes two sigma onto it. You do 102 percent of reactor power. All these different factors you're putting into the deterministic calculations. You try to maximize what you need for containment accident pressure.

So when we went over to our committee and were creating the topical report, we decided to add an appendix in it which says, "All right. If you have the DBA LOCA and your single failure was loss of containment, no other single failure, just loss of containment, where are you?" That is what this curve is trying to represent.

If you look at it right here, I have my limiting pump. The Monticello or the example plant is B RHR pump. And what this curve is showing is the amount of wetwell pressure required for NPSHa to equal

NPSHr.

What it shows is I have a line across there, atmospheric pressure. Seeing how it is less than atmospheric pressure, you do not need any containment accident pressure for this.

This is done statistically. That is why I am calling it realistic. This is the 95/95 percent curve with HWW min. So in trying to make sure that it is the correct one to ahead and compare it to.

MEMBER SHACK: But that is not what we would normally call a DBA LOCA when you assign the only single failure to the containment integrity.

MR. WOJCHOUSKI: That's why I went over it very specifically in saying that it is slightly different. That is why the other curves in the LTR show a DBA LOCA with your loss of single failure.

For Monticello, it's one of the diesels. I have both of those in there. And then if you go ahead and throw on loss-of-containment accident, you could see what toes on with that. So that's in the topical report.

This is not your typical DBA LOCA, but I wanted to use that terminology for everything except for the single failure. So it's a good clarifying question. Thank you.

Okay. Last one. Kind of a defense-in-depth type of sheet. For long-term NPSH, it can be maintained by operator actions by increasing suppression pool water level when there is no accident pressure available.

What I'm saying here is you've got your DBA LOCA. You've got your loss of your diesel, typical one. If you go ahead and have an additional operator action to go ahead and take water from an outside source and put it into the containment, you can go ahead and, one, reduce the temperature of the suppression pool; two, elevate, get an elevation head onto that. And by doing those two things, you can go ahead and make it so you do not need containment accident pressure.

Another thing that I will go into, alternate injection systems can increase the suppression pool water level and may pay the reactor vessel water level.

The EOPs and SAMGs have procedures in them for alternate injection systems. They have to consider many possibilities besides design basis, many beyond design basis, in which you lost your ECCS systems, for one reason or another.

So what you can go ahead and do is you can line up RHR service water, you can line up condensate service water, line up fire water, including the diesel fire pump, which we have had independent power supply, or service water.

Depending on which ones are available for the scenario that you're going through, if you have those systems available and lined up, you can either inject it right directly into the core, or you can line it up and inject it into the suppression pool, thus raising up the level into to it to compensate for your CAP.

VICE CHAIR ARMIJO: How long would that take -- do you know? -- for a big suppression pool to raise the water level a foot or two?

MR. WOJCHOUSKI: We went ahead and did a kind of sensitivity study on it and went ahead and assumed that you lost containment accident pressure and you took one hour to identify that that was going on and started RHR service water, one pump, from our river and put it into the containment on that. And it would run for about an hour to get to the level right underneath our vacuum breakers.

We said, "Let's stop there. So don't get rid of the vacuum breakers. But if you really had to breach the containment, you could go flood it even higher."

On that particular sensitivity study, we found that the temperature doesn't get high enough, that you need COP. We mentioned that briefly to the staff. We're looking at it. We have not formalized calculations on it, but it's an idea that can be looked at closer and finalized. And calculations will be made on that.

With COP, you don't need accident pressure at the beginning of your accident. What it takes is your temperature of your torus to heat up to a range that that is when you start needing it. So you do have the example plant, Monticello. We've got about an hour and 20 minutes or so, hour and a half before you need containment accident pressure.

There is time there to identify that you have lost containment accident pressure if it's lost or beginning of the -- if you go ahead and turn out these other systems to provide either makeup water to the torus or you can directly inject it right into the reactor vessel.

One consideration if you inject it into the reactor vessel, that provides you clean water in the reactor vessel, got a large break in it. It flows out of that break and right down in the torus and fills your torus, too. So you're doing both functions.

I want to just put this out because it's probably not the normal defense-in-depth, but it's an argument that you can say, "That's what we had, the EOPs out there and SAMGs. And we've got procedures right now that go ahead and use these systems. You can inject either into the reactor vessel or you can go ahead and do it into our containments."

MEMBER STETKAR: I guess, Alan, I can think as kind of a former operator -- not a boiler operator. So I have to be careful. If, as you say, you don't need it into the first hours until the suppression pool gets hot enough, well, during those first hours, at least my RHR pumps are still running. They don't know that they're going to fail.

MR. WOJCHOUSKI: Right.

MEMBER STETKAR: Probably I don't know unless I have been told that they are going to fail. RHR service water probably likes to keep running for those pumps in the RHR cooler. So I probably as an operator don't want to realign my RHR service water system unless I am being really clever about trying to think about things that I don't know or are going to happen and take cooling water away from things that I thought were good.

Now, some of the other systems you imagine, maybe fire water if I am really good, but capacities of those systems tend to be a lot lower than your RHR service water systems. We have to be a little careful, I think.

MEMBER BONACA: I don't want to redesign my plant in a situation where I have to depend on these kinds of means to achieve objectives of design. I mean, I don't want to degrade my ECCS performance. Essentially why did I have to depend on this?

I appreciate what you're telling me. It can be done. Probably it will be successful and so on and so forth. I think it's just because we are in a situation where the design could be restated enough that you depend on these actions.

MR. WOJCHOUSKI: Well, what I am trying to make a distinction here is that there are design basis scenarios that we design for right now and we meet. Just go ahead and have our DBA LOCA with a single act of failure where a single act of failure is a licensing basis. If you throw on a loss of containment on top of that, it is really beyond our design basis.

And, therefore, what I am trying to point out is the industry, BWR industry if you want to just make it simple, came up with a set of procedures, the EOPs and SAMGs, to try to systematically address things that are beyond their design basis to give the operators success paths.

And that is what I am trying to point out, is there are those procedures out there. They can provide a success path. It's a type of consideration for the defense-in-depth. And that's what I'm just trying to -- just a different viewpoint.

MEMBER BROWN: Why couldn't you just raise the suppression pool water level higher and higher and just leave it there, as opposed to letting it operate lower? And then you don't need it at all.

MR. WOJCHOUSKI: Good question. What we have right now is a particular design with torus loads in which a concern comes down and Mark 1 loads, in which during the initial part of the break and blow-down, you take all the nitrogen and the steam down the vent header, down the downcomers, which is about two feet.

You have a slug of water that's inside that, in that downcomers. And as that pressures it, it takes that slug of water and slams it against the very bottom of the torus.

We had to do extensive mods on our containments back in the end of the '80s, beginning of the '90s. I can't remember the exact date. And we have a very small band that we're allowed to operate within.

We already cut off about a foot of our downcomers to address that particular issue. To go ahead and do that further, we could probably get a little bit but not all the way up to the vacuum breakers valves. That would be a total redesign of the internals of the torus.

I don't know if I have my backup slides. If you can like, I can try to -- I had show you the picture of the primary containment last time with the torus, the vent lines coming down, the vent header that connects those all up, which runs around, and then the downcomers off of that.

What the Mark 1's load is worrying about is chugging loads with the pulsations and the water slugs. So if I try to get it to the same level as what we had in that sensitivity analysis, you would have to raise all the internal piping and structures inside the torus, build a new torus.

So I hope that kind of gave you an explanation. We helped to a little extent, but you wouldn't get all the way with our current force.

MEMBER BROWN: But it is okay to fill it up later.

MR. WOJCHOUSKI: Okay to fill it up later after you have already passed all the loads, you have had your blow-down, it's done with, you're an hour into the event. Now if you put water into it, you're not worried about those chugging loads. The containment is designed so you can fill it all the way up to the very top vent. And we've analyzed for that.

So if we wanted to, we could flood the torus, flood the drywell, flood it over the top end of the core and get up the top vent to the drywell.

MEMBER BROWN: You are really making an argument for why the plants originally approved in their initial licensing basis with a CAP could be left alone.

MR. WOJCHOUSKI: Probably.

MEMBER BROWN: That is another way of phrasing it.

MR. WOJCHOUSKI: Yes. Okay.

MEMBER SHACK: Any more questions?

MR. WOJCHOUSKI: I have another page.

MEMBER RAY: Bill, I know you are very late. I have got to say one thing if you can indulge me for 30 seconds. I guess I was just so shocked by what I heard Marty say. It's not for you. I was too slow reacting before you got up there.

I do understand what backup criteria are for. They are to provide licensing stability and to avoid what was going on before, which were changes being imposed on the industry all the time. So it's a very low threshold.

I have never heard that applied to modifications to changes being proposed, modifications that the staff would require of changes being proposed by a licensee as a limit on those modifications. That blows my mind to even think about it. But, in any event, I wanted to say that now so that --

MEMBER BROWN: Do you mean for power uprate conditions?

MEMBER RAY: For any change. You come in and you say you've got to make this mod to this change, and you say, "No. It cost me more than $74,000. I won't do it." I have never heard of such a thing.

So if that's the way things are being done nowadays, I think we ought to reflect on that, too.

MEMBER SHACK: Okay. Well, we are behind schedule. We were supposed to start another one, but

I think this is a good place for a break.

CHAIR ABDEL-KHALIK: Yes. So we will take a break for 15 minutes. We will be back at 3:15. At that time, Sam will be chairing.

(Whereupon, the foregoing matter went off the record at 2:55 p.m. and went back on the record at 3:13 p.m.)

VICE CHAIR ARMIJO: Okay. Let's get started again.

Bill, introduce your next speaker, please.

MEMBER SHACK: Okay. It will be Rich Lobel and Ahsan Sallman talking about the use of containment accident pressure in determining available NPSH.

MR. LOBEL: Okay. Good afternoon. My name is Richard Lobel. I am a Senior Reactor Systems Engineer.

MEMBER SHACK: Can you bang F5, so we get a full screen?

MR. LOBEL: What do I do?

MEMBER SHACK: F5.

MR. LOBEL: Oh, okay. Senior Reactor Systems Engineer in the Office of Nuclear Reactor Regulation. With me is Ahsan Sallman, who is a Reactor Systems Engineer in the Office of Nuclear

Reactor Regulation.

We briefed the Subcommittee on April 23rd, and I will repeat some of that presentation and also address the questions raised by that meeting.

Do you have a time I should finish by, so I can kind of adjust, or just do my presentation?

VICE CHAIR ARMIJO: I'm willing to run late. This is an issue that, you know, we need to give it as much time as it takes --

MR. LOBEL: Okay.

VICE CHAIR ARMIJO: -- to make sure everybody understands it.

MR. LOBEL: Following receipt of the March 18, 2009, letter from the ACRS to the Executive Director of Operations, we took a more detailed and comprehensive approach to the issue of using containment accident pressure. And we are here today to discuss our approach with you and get your comments.

The significant aspects of the approach have already been mentioned today but are important. The focus on pump performance, trying to get away from just speaking in terms of containment pressure and margin in containment pressure, and that kind of thing. We tried to focus more on pump performance.

We have information that was provided to us by two recognized experts in pump cavitation and NPSH, and also we attempted to do our own calculations for this study.

MEMBER RAY: Rich, there was a presentation last time that had, you'll recall, the band and a lot of the -- just glancing here, I didn't see it, and I just wanted to make sure you are going to address that --

MR. LOBEL: It should be in there.

MEMBER RAY: -- data set.

MR. LOBEL: I am.

MEMBER RAY: All right. Thank you.

MR. LOBEL: Okay. It was suggested that it would be useful to talk about the difference between overpressure and containment accident pressure, and we talked about this with the Subcommittee, too. We were trying to get away from using the word "overpressure" for two reasons.

One is that really nothing is being overpressurized, and the second reason is that different licensees have used different definitions of "overpressure" as shown on the slide -- greater than atmospheric pressure, greater than saturation pressure, greater than the containment pressure prior to the accident. And so we have been speaking in terms of containment accident pressure, which is simply the pressure caused by whatever postulated accident we are talking about.

There are 27 operating reactors that use containment accident pressure, 19 BWRs. They are all BWRs with Mark I containments, the torus design of containment.

MEMBER CORRADINI: They all are?

MR. LOBEL: All 19.

MEMBER CORRADINI: Okay, yes.

MR. LOBEL: There are eight PWRs, sub-atmospherics, and large dries -- large dry containments. As far as the status goes, there are -- as you know, there are two EPU reviews, extended power uprate reviews, that are on hold pending revision of the guidance we have been using for review that I will talk about in this presentation.

Some of the key ideas or key issues are that we are considering design basis and special events for the deterministic part of this analysis. Marty talked about reactor safety in a more general way, but when we talk about applying these guidelines, they would be applied to design basis events and special events.

Containment integrity is assumed. We are proposing a new criterion to ensure against pre-existing leaks that I will talk about. We are addressing Appendix R, fire-associated circuit issues, in -- as part of the review, and also reviewing to make sure that there are no procedures that would require operators to vent the containment at the same time that credit is being taken for containment accident pressure.

(Laughter.)

Sounds obvious, but it isn't.

(Laughter.)

It is a question worth asking.

The staff guidelines, like I said, are focused on pump performance, NPSH margin, and adverse effects on the pump. And, where possible, we have tried to use quantitative guidelines.

One other point I would like to make before we go on. We spent quite a bit of time I think at the Subcommittee meeting talking about staff calculations. And I am prepared to talk about it again, but I wanted to make a point about the calculations.

The staff calculations aren't licensing calculations. We made best guesses at some variables and some input parameters and made some assumptions that may or may not be close to what licensees would use. So it is really not worthwhile to look at the staff calculations in terms of the exact values that we obtained.

The purpose of the staff calculations were first to develop the capability, and to study trends and to compare relative values, statistical with realistic to conservative. The staff audit calculations done as part of our license review would use input that is more carefully selected and that we would discuss with the licensees to make sure that we were using values, because part of the review of a licensee's submittal when we do calculations is to look at the input and to do our own assessment of the input and make sure that the input is reasonable and satisfies whatever the review criteria are for that event.

With that said, let me go on to the approach we took. We tried to do things quantitatively, looking at margin and uncertainty, and this slide illustrates the approach we took. It is a plot of NPSH for some event, as a function of time. There are two horizontal lines towards the bottom of the curves that are the required NPSH curves. And one of them is the three percent value.

We decided that we would use the three percent required NPSH value as kind of the starting point for our work. The --

MEMBER CORRADINI: Can you just define that again, just so I understand it?

MR. LOBEL: Required NPSH?

MEMBER CORRADINI: No, no. That part I know. The three --

MR. LOBEL: The three percent?

MEMBER CORRADINI: -- percent.

MR. LOBEL: I'm going to get the next -- because the slides are going to get into it.

MEMBER CORRADINI: Okay. Excuse me.

MR. LOBEL: Basically, what it is is when you get enough cavitation in the pump, the head the pump puts out starts to decrease, and that is measured and the three percent drop in head is -- the NPSH corresponding to the three percent drop in head is called the required NPSH.

So we used the three percent value to start with, and then, with the help of our pump consultants, we assessed the uncertainty on that value, and then we also looked at the available NPSH, and in terms of the nominal available NPSH, which would be the expected value of available NPSH and the conservative value of NPSH, and the difference between those is one definition of uncertainty -- actually margin, it's not really uncertainty.

But what we're calling the margin is the difference between the required NPSH and the available NPSH. That is one definition of margin. Another definition that we use is the difference between the nominal available NPSH and the conservative available NPSH, and that gives us two ways of looking at the margin in these calculations. And it is done in terms of NPSH, so it is done in terms of what the pump is experiencing.

Let me go through a little bit about what cavitation is and how we view it. Cavitation is -- I'm sure you know is the formation of vapor in a liquid due to a decrease in the local static pressure followed by an increase in the local static pressure that results in the sudden condensation of the vapor. And this occurs at a constant liquid temperature.

Excessive cavitation can result in erosion of the pump impeller and other pump parts, mechanical damage to seals, bearings, and shaft, decrease in pump flow rate, decrease in pump discharge head, and vibration. The degree to which any of these effects adversely affects the pump performance depends on the amount of cavitation and its duration.

The air or gas content in liquid, the suction energy of the pump, and the NPSH margin, which is the difference between the available and the required NPSH, and if the pump is operating in a low flow region we call the suction recirculation region.

This slide is a plot of total head. Actually, it's called the total dynamic head that the pump puts out. It's the difference between the suction head and the discharge head of the pump, and it is a measure, really, of the energy that is added to the liquid by the pump. And this is the way a typical test result would look, and this gets to what I was describing before.

The best might be a tank of water that the pump is taking suction from, and then the pump returns the discharge back to that tank. The test would be run at a constant flow rate and a constant pump speed, and you can see at high values of available NPSH the pump is putting out a constant head. It is doing what it was designed to do for those conditions.

As the available NPSH is decreased, the pump will still put out the desired head until it reaches a point where the available NPSH becomes low enough that the pump has cavitated enough that it can't any longer supply the same energy to the liquid, the same total distance, the same total head, and the curve gets a knee.

The three percent value of NPSH corresponds to the test available NPSH when there is a three percent drop in head. And this is the kind of test that is done in the -- and the required NPSH values are then plotted as a function of flow, because the test is repeated for different flow rates.

VICE CHAIR ARMIJO: With the pump operating under those conditions, there is cavitation going on and --

MR. LOBEL: Yes.

VICE CHAIR ARMIJO: -- that is acceptable, but you could run forever that at that --

MR. LOBEL: I am going to talk about that in the next slide, or the next slides.

MEMBER BROWN: Q^1, Q^2, Q^3, are three different flow values?

MR. LOBEL: I'm sorry.

MEMBER BROWN: Are Q^1, Q^2, Q^3 three different flow values?

MR. LOBEL: Yes.

MEMBER BROWN: Okay. I was --

MR. LOBEL: Yes, sorry. Yes.

MEMBER BROWN: Okay.

MEMBER CORRADINI: Just so I'm clear, so at a higher head the flow rate is higher, so Q^1 is smaller than Q^2 is smaller than Q^3, right?

MR. LOBEL: It doesn't have -- it is really where the tester is setting the flow. He adjusts valves to get a certain flow rate and it --

MEMBER CORRADINI: Yes. But with the normal pump curve, it looks like this.

MR. LOBEL: Yes.

MEMBER CORRADINI: So Q^1 is smaller than Q^2 is smaller than Q^3?

MR. LOBEL: Q^1 is larger.

MEMBER CORRADINI: Larger.

MR. LOBEL: Isn't it? Q^1 --

MEMBER BLEY: You will have a lower head when you've got --

MEMBER CORRADINI: Lower head when you have more flow.

MR. LOBEL: More flow, lower head is more flow.

MEMBER CORRADINI: Okay. So that's one thing I want to make sure of. And the second thing is, then, the curve with the NPSHR is not a line, it is a curve, depending upon the required flow, so you show it as a line. That means you are assuming a flow.

MR. LOBEL: For each one of these -- for each one of these curves I get one value of --

MEMBER CORRADINI: Right.

MR. LOBEL: -- three percent head drop.

MEMBER CORRADINI: But you had the cartoon previously -- you don't have to go back to the cartoon -- where you had -- you described what you termed "margin."

MR. LOBEL: Yes.

MEMBER CORRADINI: The dashed line is not a line. It's a function of what is the required flow at a certain point. So margin is --

MR. LOBEL: Oh, right.

MEMBER CORRADINI: -- dependent on the required flow condition.

MR. LOBEL: The reason it's a horizontal line is usually when we do our calculations we assume only a constant value.

MEMBER CORRADINI: So that's why I'm back to the Q^1, Q^2, Q^3. So somehow you have keyed into a particular Q to get a particular --

MR. LOBEL: Yes.

MEMBER CORRADINI: -- NPSHR.

MR. LOBEL: Yes.

MEMBER CORRADINI: Okay.

MR. LOBEL: Yes.

MEMBER CORRADINI: And that doesn't change, so I'm trying to decide -- I'm trying to decide which one do I worry about in the accident timeframe? Is it always the largest Q^3?

MR. LOBEL: In the accident, a flow rate is chosen for the safety analysis. The pumps are assumed to be putting out a certain flow, and so that is why you have a constant --

MEMBER CORRADINI: Okay.

MR. LOBEL: -- required NPSH. And it isn't physically what would happen, but it is what --

MEMBER CORRADINI: Right. But where I'm going with this is, so I'm just trying to make sure I fold all the things together. Where I'm going with this is the highest required NPSHR, is it the largest Q?

MR. LOBEL: Yes.

MEMBER CORRADINI: Okay.

MR. LOBEL: Yes. The curve increases with flow.

MEMBER BLEY: Now, before we leave that, I want to ask the question I didn't ask when Alan was up, but it's really kind of aimed at him. At our last -- at the Subcommittee session, I think it was Alan said -- and somebody from staff also said -- in some of the BWR emergency procedures there is a step for if you're having trouble with net positive suction head for throttling down on the flow, which this supports, net positive suction head required drops off.

We have asked for copies of the procedure that show that and haven't seen them. And I didn't see that specific action on Alan's chart when he was up. So if somebody from staff and maybe Alan would want to address, is this an action in the procedures to cut back flow less than the accident analysis to retain net positive suction head? Is that true? And can you guys provide us with copies of this procedure, so we can understand it? And how do you make sure you're not violating the accident analysis?

MR. HAMMER: I'm Steve Hammer. I'm from Monticello. I'm currently the EPU Licensing Manager. I've been at Monticello for about 35 years, past SRO, engineer, and design.

We did send those curves to -- actually, to Peter Tam. It was through a request from ACRS after the last meeting.

PARTICIPANT: Okay. They haven't made it to us yet, so we're still looking for them.

MR. HAMMER: It does look like this. We've only got one copy of it. We need to make copies of that.

Right now, this exists in EOPs primarily as a caution. And what it does is any time you are using a core spray pump or an RHR pump it does caution you to look at the NPSH curves, and the curves provide a picture of flow versus containment pressure at various flow rates to show what the NPSH requirements are.

And it just basically states that, you know, if you operate outside of those limits you could damage the pumps is what it boils down to.

MEMBER BLEY: We would still like to know -- get pointed to where in the procedure it --

MEMBER STETKAR: Do the instructions specifically tell you to throttle back on flow to get back within those curves, or does it just say --

MR. HAMMER: The EOPs are --

MEMBER STETKAR: -- beware of this?

MR. HAMMER: -- symptom-based curves, and so they are intended to address a broad range of possible accidents, including beyond design basis events. So in some cases what -- it is left up to the operators to a certain extent. If you're in a design basis event, they encourage you to stay within the pump NPSH limits.

If you're in a situation where you need that flow, you know, the operators are given the latitude to operate at higher flow rates for a period of time to try and keep the core cool.

MEMBER BLEY: I guess we would still like to see that, because that's not -- that's not the kind of thing we've been showing up in the justifications for CAP credit under power uprates. It is the one about pumping up containment pressure a bit.

MR. HAMMER: Well, the deterministic analysis is done, as Rich has pointed out, based on a specific flow rate. We don't have an analysis that is provided at a lower flow rate. You know, for Monticello, the containment heat removal system is assumed to operate at 4,000 gpm for RHR. So we don't have an analysis at a lower flow rate.

You're right, we could throttle back a little bit, but it would be --

MEMBER BLEY: It wasn't my idea. It was presented at a Subcommittee meeting.

MEMBER SHACK: It sounded like you really don't throttle back.

MEMBER STETKAR: I was asking whether there was a step --

MR. HAMMER: Well, the operators are cautioned, and they are pointed -- they are encouraged to stay within the NPSH limits. They are just -- the caution is --

MEMBER SHACK: But if he needs flow, he gets it.

MR. HAMMER: If it needs flow, yes, they are --

MR. LOBEL: The first priority is the core and the --

MR. HAMMER: Yes. And in the basis for the procedures that's what their basic -- most of the cautions are aimed at that -- keeping the core cool, or aimed at, you know, protecting the fuel.

MR. LOBEL: But I have -- I am not an operator. I have been in control rooms and talked to operators and asked them, "What would you do?" and that's one of the things operators say that they would do if they needed to.

And we have talked about indications. We, the staff, have asked that question -- asked the question of, what indications would you have of difficulties with the pump and NPSH problems with the pump? And what would you do when you saw those indications? And the response is fairly uniform.

MEMBER STETKAR: In a calm control room answering questions to a person asking about: what would you do about this pump?

MR. LOBEL: Well --

MEMBER STETKAR: You are doing this during the middle of a simulator exercise where -- okay, thanks.

MR. LOBEL: But, you know, that's what operators are there for. They are there to handle those kinds of events.

MEMBER STETKAR: Mostly they are there to make sure the core keeps cool enough.

MR. LOBEL: Well, if you lose the pumps -- okay. So what we tried to do with required NPSH was assess what the uncertainties could be in required NPSH, starting with the testing done at the vendor's facility with the pump, and then asking, how would that uncertainty increase when the pump is installed at the plant?

And the things that were considered were differences in pump speed, water temperature, the suction piping layout, which can have a big effect on required NPSH, air content of the pump water, and wear ring leakage that can have an I think surprising effect on required NPSH.

We defined a new variable that we called the effective required NPSH to include the uncertainty values. And we are still discussing what that uncertainty should be with the BWR Owners' Group, and have gotten our own estimates from our pump consultant. And so we haven't settled on final values of an uncertainty yet, but these are the things that we've identified that need to be considered.

MEMBER CORRADINI: But it would be no -- I guess I understand what you're saying, but from the standpoint of just practicality, it would be no greater than a value where you see no degradation, right?

MR. LOBEL: Well, no, this would -- I'm not sure I understand what you mean, but this would --

MEMBER CORRADINI: If NPSH is four feet at the three percent test matrix --

MR. LOBEL: Right.

MEMBER CORRADINI: -- and they saw no degradation at 4.2 feet, it can be no greater than 4.2 feet.

MR. LOBEL: Well, yes. Yes, I think --

MEMBER CORRADINI: That's all I'm trying to say is that at some point they run the pump, run the pump, and it doesn't degrade.

MR. LOBEL: Well, what we're talking about now, that was the three percent value that they got from the test, and that had whatever test uncertainty there was. Now we're talking about the pump installed and other uncertainties, and those -- that uncertainty would be added on for doing the calculations, the accident calculations. So --

MEMBER CORRADINI: So this is additional uncertainties, because it is not that pump, it is not that test regimen.

MR. LOBEL: Different conditions.

MEMBER BROWN: Well, it's uncertainty, because the -- let me -- I'm confused about this also. It was in your paper. The three percent is a value. Let me back up even further. You run your pump in your factory, and you -- based on some constant conditions, and you get a number --

MR. LOBEL: Right.

MEMBER BROWN: -- that's required.

MR. LOBEL: Right.

MEMBER BROWN: Then, you run -- you can then determine what three percent is based on the head loss in the factory in your test configuration.

MR. LOBEL: Right.

MEMBER BROWN: When you go put it in the plant, your paper, as well as what you're saying, is now there is other installed configurations that really say the number is higher than the three percent.

MR. LOBEL: Yes, right.

MEMBER BROWN: Which you have defined as your baseline -- you can't go below that.

MR. LOBEL: Right.

MEMBER BROWN: So, to me, you have really raised the baseline of which you shouldn't go below.

MR. LOBEL: Right.

MEMBER BROWN: But yet you are defining the difference between that efficiency -- EFF and three percent as margin, when you --

PARTICIPANT: No, uncertainty.

MEMBER BROWN: Well, that's what it -- no, it says value is to be used -- it says NPSH EFF should be used in determining the margin. Do you mean the margin to what number, the three percent, or the one percent?

MR. LOBEL: I should -- yes, that's confusing. I should say just NPSH margin. Yes, that's confusing.

MEMBER BROWN: It says required margin.

MR. LOBEL: Yes.

MEMBER BROWN: The R is on there.

MR. LOBEL: Yes.

MEMBER BROWN: And that's the way it's phrased in your --

MR. LOBEL: In fact, I was looking -- I just added that. I don't think that was there for the Subcommittee. For some reason I just added that.

MEMBER BROWN: Well, it is in your guidance paper.

MR. LOBEL: Okay.

MEMBER BROWN: It says NPSHR decreases and increases in --

MR. LOBEL: The effective NPSH is -- the effective required NPSH, compared with the available NPSH, would show a margin. That's what we're trying to say is the margin.

MEMBER BROWN: Okay.

MR. LOBEL: The effective required --

MEMBER BROWN: If available --

MR. LOBEL: -- to available --

MEMBER BROWN: Here is the pristine factory number without the three percent.

MR. LOBEL: Okay. Here is the pristine factory. Add the uncertainty to that, and then compare that with the available -- the effective with the available.

MEMBER BROWN: And that's the margin.

MR. LOBEL: That's the margin. Yes, sorry.

VICE CHAIR ARMIJO: Is that uncertainty number going to be in your guidance a fixed number or plant-specific, each plant has to calculate that?

MR. LOBEL: I don't know. I think that depends on discussions with the Owners' Group.

VICE CHAIR ARMIJO: Or how different the different plants are and --

MR. LOBEL: From discussions that I have had with pump experts, it is not a very easy uncertainty to obtain. Pump experts tell me that they can tell what the margin is between -- margin until you get to some undesired effect. But what the uncertainty is isn't something that they ordinarily deal with.

And so what we got from our pump consultant was his estimates of these different uncertainties. And where we go with that I guess I'm not sure yet, but it is something that we're saying needs to be considered.

MEMBER POWERS: When you indicate that you worry about the air content of the pumped water, is there -- and that is primarily nitrogen solubility -- is hydrogen solubility significantly different that it needs to be separately considered?

MR. LOBEL: Hydrogen?

MEMBER POWERS: Yes.

MR. LOBEL: I am trying to remember. Oxygen is pretty close. I guess I'm not sure offhand. I think it's higher, but I -- but I don't want to -- I don't want to --

MEMBER POWERS: Whatever it is, we can be sure that it changes as temperature of the sump water changes.

MR. LOBEL: Yes.

MEMBER POWERS: That one we know.

MR. LOBEL: Yes. And these -- we are talking about very high -- relatively high temperatures here. So there isn't a whole lot of nitrogen in the water at 190, 200 degrees. But there is still some.

MEMBER POWERS: Henry's Law coefficient goes through a minimum and starts climbing back up. I mean, presumably, if it was critical, the solubility would be 100 percent. So it has to go up someplace.

MR. LOBEL: And the other issue with nitrogen or air is -- well, we'll get to that. That -- I was -- there is a mechanical effect from the air, too. Right now we are just talking about the effect on required NPSH, but there is also a mechanical effect on the pump, too.

MEMBER BANERJEE: Is there any radiolysis-generated gases?

MR. LOBEL: If you have fuel failure, yes.

MEMBER BANERJEE: Well, what about -- I mean, isn't the water pushing subject back to --

MR. LOBEL: In a LOCA, if you had fuel failure, yes, there would be some radiolysis.

MEMBER CORRADINI: But I think what he's asking -- I guess we're jumping -- I thought what he's asking is from a DBA calculation. You have to assume some radiolysis rate, which would be there even without fuel failure, right?

VICE CHAIR ARMIJO: Right.

MEMBER POWERS: I would expect that the bounding one percent core-wide oxidation would exceed radiolysis at least for the first 72 hours.

MEMBER CORRADINI: You think so?

MEMBER POWERS: Yes, the radiolysis yields a huge -- one percent core-wide oxidation is the limit. Now, I don't know what they do when they have actual calculation, whether they take the plant-specific value or that limit, but I would expect that would be more than what you'd get for radiolysis for the first few days. And then, eventually radiolysis kills, but it takes a while.

MEMBER BANERJEE: Yes. For the GSI problem, we have been concerned about gas bubbles. So I don't know where that fits here, but --

MEMBER POWERS: It would be interesting to run through a calculation.

MR. LOBEL: Which GSI?

MEMBER BANERJEE: GSI-191.

MR. LOBEL: 191? Oh, okay.

MEMBER RAY: Rich, I've been running around trying to find this curve that I asked you about earlier. This is what we looked at last time. It had the green band in it. I've found it now.

MR. LOBEL: It's your Slide 12.

MEMBER RAY: Ah, okay. I stopped. Sorry. It just didn't have green on it.

(Laughter.)

And I wasn't sure I was looking at --

MR. LOBEL: You should have colored

copies.

MEMBER RAY: Well, but we don't.

(Laughter.)

We don't, and I --

MR. LOBEL: They were made, and they were delivered. I don't know what happened.

MEMBER RAY: Forgive me. Let me get Slide 12 then.

MEMBER POWERS: Somewhere there is a kindergarten class with --

(Laughter.)

MR. LOBEL: Somehow I just didn't pick it out when I scanned the --

PARTICIPANT: Unless they color between the lines, you're okay.

(Laughter.)

MR. LOBEL: Okay. Another point about cavitation is there is a point of maximum cavitation erosion, which is between the point of incipient cavitation, where you first get bubbles forming, vapor forming, and the three percent head drop value.

Let me go to this slide. This is that same testing curve of head versus NPSH, and what I wanted to show was how the behavior changes with -- at the different points on this curve due to different amounts of cavitation. If we start at Point D, which is the breakdown point of the pump, the pump just isn't pumping anymore, at that point the pump impeller is pretty much just surrounded by vapor. There is so much vapor formed that the pump is just spinning in vapor.

At the three percent head value, the Point C, there is a lot of vapor, a huge volume of vapor, that still exists, as well as some bubbles that collapse as they move through the impeller to regions of higher pressure. And the collapsing of the bubbles can cause some pitting or erosion of the impeller.

The flow rate can also be unsteady and can affect the seals and the bearings and that kind of thing at the three percent value. The next point, Point B, as we're going to the right, is a point where there are a lot of entrained bubbles in the liquid, and there is also a lot of liquid.

So there is not much mitigation of the pressure pulse and the micro-jet from the collapsing of the vapor bubbles. And that is the point where you get the most maximum erosion, maximum pitting of the impeller, and maybe other pump parts. And that point is hard to pinpoint. It is not defined that well.

Point A is the point of incipient

cavitation. At that point, you just have some vapor bubbles forming in the liquid, and it has no effect on the pump.

MEMBER BROWN: But if you wanted to --

MEMBER BANERJEE: The point -- sorry.

MEMBER BROWN: Go ahead. No, go ahead, Sanjoy.

MEMBER BANERJEE: If you have dissolved gases, of course, you would get much lower effect at Point B.

MR. LOBEL: Yes.

MEMBER BANERJEE: The erosion is much reduced, even with the lower boundary of --

MR. LOBEL: Yes, I'm going to talk about that on the next slide.

MEMBER BROWN: I thought Point B was a maximum erosion zone.

MEMBER BANERJEE: I am simply saying that if you have dissolved gases it -- you know, the jet he is talking about due to a collapsing bubble, basically that gets very attenuated if you have a non-condensable gas.

MR. LOBEL: Yes, let me --

MEMBER BANERJEE: He is going to talk about it.

MR. LOBEL: Let me show you on the next slide.

MEMBER BROWN: I was coming to the conclusion it was better to go from Point B to C and get there fast, so you don't damage the rotor or the impellers, even though there is more bubbles in those.

MR. LOBEL: This slide is an illustration of an actual measurement of cavitation in a pump, and what it shows -- again, it is the relative erosion rate. Actually, it's the relative noise rate due to the cavitation, which is pretty much the same thing as the erosion rate versus the NPSH margin ratio.

And you can see that at high NPSH margin ratios there isn't relatively much cavitation going on. As the available NPSH decreases, the amount of cavitation increases until you get to a peak. And at that peak, on the other side of that, as the ratio decreases more, the amount of noise from cavitation, the amount of damage actually decreases, and that is due to the air -- partially to the air coming out of solution and mitigating the pressure effect of the collapsing bubbles, and also the vapor, the amount of vapor that also has a mitigating effect.

MEMBER BANERJEE: Can you explain what you mean by the margin ratio?

MR. LOBEL: It's the available over the required.

MEMBER CORRADINI: But just to be clear, I think I know what you're saying, but just to say it differently, this has to be relatively clean water. The gassier the water, the peak will lower and it will broaden, and you actually -- right? If I have more gases in solution, that erosion rate -- that peak will go down, and I will see -- I will actually see cavitation earlier and different sort of erosion.

MR. LOBEL: You could. The other effect --

MEMBER BANERJEE: That's the question we are asking, right? I don't know the answer to that.

MR. LOBEL: The air has a mitigating effect in terms of the damage that is done, the pitting, the erosion that's done. The air also has an effect of increasing the required NPSH, because it contributes to the blockage at the entrance to the pump impeller blades.

MEMBER CORRADINI: So you get less -- the way I was going to say it is you get less erosion -- you get less erosion, but you get an earlier degradation of flow rate.

MR. LOBEL: Yes.

MEMBER CORRADINI: Yes.

MR. LOBEL: Yes. Okay. Now we get to this curve.

MEMBER RAY: The one I've been looking for.

MR. LOBEL: Okay. So what do we do with the information that we've got so far? We did a calculation for a BWR Mark I containment with the NPSH ratio as a function of time for a large break LOCA. And, oh, I didn't -- I didn't mention something on this side.

We used a curve like this to define the bands for this maximum erosion rate, and we choose 1.2 to 1.6 for the region that you would get the maximum erosion based on this type of curve. So looking at this curve, we are defining this green band as the band of maximum erosion. And we are saying that you shouldn't be in this band for more than 100 hours.

The 100 hours we think is a very conservative number. Again, it is a number that is very hard to define. And talking to pump experts, both our consultants and others, they seem to think that -- some say that you could go to even an order of magnitude higher than the 100 hours and still be okay.

And so one of the things we are hoping to resolve in discussions with the Owners' Group is just where that boundary should be. Should it be 100 hours, or should it be more than that?

MEMBER BLEY: Rich, can you back up one slide? I just wanted to say something in support of that point. If this curve is real -- I don't know if it is or not.

MR. LOBEL: It is from data.

MEMBER BLEY: It is kind of tailing off. So even if you have very high pressure, you are still having erosion, if that scale is right. I mean, in the worst case it is about four times what it is at the highest pressure you have. So that kind of says it isn't going away real fast or your pump, under its good conditions, would go away terribly quickly.

MR. LOBEL: And this is a pretty --

MEMBER BLEY: And we know it doesn't do that.

MR. LOBEL: It is a pretty well recognized phenomena. There are a lot of papers that talk about this type of thing. Maximum erosion zone is probably our words, but there are a lot of pump papers that talk about this phenomena.

MEMBER RAY: But most of us have thought about wanting to keep the ratio above one, and that was -- that was sufficient. But this tells us something more, and I --

VICE CHAIR ARMIJO: It's much higher than one.

MEMBER RAY: Right.

VICE CHAIR ARMIJO: If you really want to be out of all kinds of trouble, you go beyond --

MEMBER RAY: Yes, yes. Normally, it means you've got to get the temperature down.

MR. LOBEL: In fact, a lot of the papers talk about it in those terms, that you thought the worst condition was at the three percent. Well, actually, that is not true, it is at higher than the three percent.

MEMBER RAY: Right, right.

MR. LOBEL: So you have to be aware of that.

But the other thing to consider when we talk about pump effects, too, is a lot of the literature that is out there, almost all of the literature out there, is for pumps at process plants -- refineries, water treatment plants, that kind of thing, where the pumps operate for a year or more than a year at a time before any kind of maintenance is done on them, and they are expected to last for that long. We are talking about a very short time in terms of that kind of thing, that these pumps would operate in these kind of conditions.

MEMBER RAY: But still, have we ever analyzed for this in accident scenarios? I --

MR. LOBEL: No, not that I know of.

MEMBER RAY: I have never seen anything. Anyway --

MEMBER BLEY: At least to me, this curve is a real hint that we probably don't need to. You've got to pursue it some more, and we would be interested to --

MR. LOBEL: But if you go below one, pretty soon you stop pumping.

MEMBER RAY: Yes. Below one, everybody knows that we can't do that very long. But this other one is just something new. I wanted to make sure I understood it better.

MEMBER CORRADINI: Well, I mean, I guess I'm -- maybe I'm not -- I'm not as worried, because there is always cavitation on the impeller blades. There is always cavitation. There is always bubbles opening and closing and -- because that's not going to go to zero. That's going to go some sort of continual erosion. It's a matter of -- it's a matter of how long you wait and how you can cook at it. So --

MR. LOBEL: And I skipped that point. I was going to say that there is a Hydraulic Institute standard that says that you need an available NPSH of four to five times the three percent value before you get incipient cavitation. And for high energy pumps, which these pumps are, it could be a factor of 20. So you could always be having some amount of cavitation in the pump.

These pumps are very robust. They are made out of cavitation-resistant material, so normally it is not an issue. And normally when they are performing their other functions, there are a lot higher available NPSH values, so it's not an issue.

MEMBER BANERJEE: Can you help me just by redefining NPSHR precisely?

MR. LOBEL: In general, without getting into the three percent -- let me try it this way. NPSH is defined at the pump suction flange, where the pump connects to the piping. There is going to be a pressure drop through the pump to the impeller, and if that pressure drop is low enough you will have vaporization in the impeller, which you don't want to have.

And so what you do is you raise the

available NPSH, which is the NPSH you got from a system at the pump flange, you raise that to a high enough value, so that you are greater than the required NPSH and you won't have vaporization at the impeller. So that's why A is greater than R.

MEMBER BANERJEE: NPSHR based on --

MR. LOBEL: R -- required NPSH is the value of NPSH, so that you get a certain amount of cavitation. Zero --

MEMBER BANERJEE: On the impeller.

MR. LOBEL: At the impeller, yes.

MEMBER BANERJEE: Which is what, three percent, or what is the number?

MR. LOBEL: Well, you can define it however you want. You can define it as incipient. You can define it as zero. You can define it as one percent, three percent. Some licensees have gone up to five and six percent based on testing they have done.

MEMBER BANERJEE: So in this sort of curve, what is NPSHR being defined as here?

MR. LOBEL: In there it was a three percent.

MEMBER BANERJEE: Okay.

MEMBER CORRADINI: But that's on flow

rate, a three percent degradation of the flow rate.

MR. LOBEL: Of head.

MEMBER CORRADINI: Head. I'm sorry, the head.

MEMBER BROWN: Just for calibration for me, the plants operated with pumps ran for years and years and years, primary coolant pumps, PWRs. And we never had a problem with flows or erosion, so I presume the NPSH margin ratio is --

MEMBER BANERJEE: Way out there.

MEMBER BROWN: -- way out. We're talking 40, 50, 60. What kind --

MR. LOBEL: Well, there's another --

MEMBER BROWN: -- that type of an application?

MEMBER BLEY: In reactor coolant pumps where you've got real high pressure.

MEMBER BROWN: Yes. I mean, they've got a tremendous amount of available suction.

MR. LOBEL: There is another factor, too, that I haven't mentioned that is very important.

MEMBER BROWN: Hold it. I didn't get my point in. My point is that 25 percent that you are -- there is always cavitation and erosion going on, but by the -- if you get way out, that thing goes -- has got to go low, otherwise you'd be damaging impellers, and you wouldn't have pumps lasting for 25 or 30 years.

MR. LOBEL: There is another factor, too, that I haven't mentioned -- well, I mentioned it very briefly -- was the pumps are classified by the energy of the pump. One of our pump consultants invented a thing called suction energy, but if you don't use that there is also something called suction-specific speed, and there is also tip speed of the impeller and things like that. There are ways of measuring the energy of the pump.

And pumps that are low energy pumps can cavitate and not do any damage. You can have aluminum and other kinds of soft materials for impellers, and the pumps will still pump and not have any damage. These kinds of pumps are high energy pumps, and they are more prone to damage from cavitation, but they also have better materials, cavitation-resistant materials, too.

So it is not only where you are with available NPSH, but there is this issue of high energy in the pump, too, that has an effect. If you have a low energy --

MEMBER BANERJEE: But high energy.

MR. LOBEL: It is really a measure of the energy that is given to the fluid by the pump. It is -- one way of looking at it is the speed of the impeller --

MEMBER BANERJEE: Is it related to specific speed in some way? No.

MR. LOBEL: Specific speed is a measure of -- is a classification of pumps, low specific speed, radial, and, you know, you can go up to mixed flow and --

MEMBER BANERJEE: But there is a precise definition for what --

MR. LOBEL: -- axial, yes.

MEMBER BANERJEE: -- it is, yes.

MR. LOBEL: Suction-specific speed is the same definition, only instead of head in the denominator you have required NPSH. And it is an indication of how well the pump is going to withstand adverse suction conditions. And a lot of pump --

MEMBER BANERJEE: So do you have the formula or something that is used?

MR. LOBEL: Yes, it is pump speed times -- pump speed and rpm times flow rate and gpm to the one-half power divided by required NPSH to the three-quarters power.

And if you do -- and this comes from a non-dimensional analysis, but people don't use the non-dimensional form.

MEMBER BANERJEE: Right.

MR. LOBEL: They use units of this. And the usual guidance is you don't want a pump to operate at a suction-specific speed above 11,000 in those units. These pumps are higher than that. They operate at a higher value than 11,000.

There is a lot of controversy in pump literature about whether 11,000 is a real limit or not, and that is what people were trying to get away from with this suction energy. Suction energy is a -- they are saying is a better measure than suction-specific speed, because it turns -- I'm probably getting into too much detail, but suction energy some people think is a better indication of the suction performance of the pump cavitation than just suction-specific speed.

MEMBER BANERJEE: Okay.

MR. LOBEL: But it's not a clear-cut, precise area, and pump companies seem to have their own guidelines that they use for designing --

MEMBER BANERJEE: The consultants who submitted a report to you on this, did they have a little discussion on this and why it is --

MR. LOBEL: Yes. The Sulzer reports that you have seen do have calculations of suction-specific speed, not suction energy but suction-specific speed and tip speed and that kind of thing. They are mentioned in those reports.

MEMBER BLEY: But your consultant's report talks about the suction energy, is that what --

MR. LOBEL: He talks -- yes, he was the inventor of suction energy, so he talks about suction energy.

MEMBER BANERJEE: Okay.

MR. LOBEL: Okay. So I think we can -- okay. So moving on --

MEMBER BANERJEE: But the green curve that Harold wanted to see --

MR. LOBEL: That's the one that was --

MEMBER RAY: Yes. I mean, basically, what it boils down to is there is a phenomena that we haven't dealt with in reactor accident -- post-accident space that says you need more long-term than just available more than required, and I was interested in that.

The comment has been made that this is something that is only of interest over a very long period. But I gather you are going to still put that to bed somehow, aren't you?

MR. LOBEL: We need to address it one way or another. Either it has to be shown that the pump won't last -- won't spend more than 100 hours in this band or we have to say that the band can be bigger -- band can be longer in time, or we have to say it's not necessary at all, and we haven't gotten there yet.

MEMBER BANERJEE: But this is a curious result, as Graham Wallis was pointing out, that you actually are better off going through that into one or something.

MR. LOBEL: Yes.

MEMBER BANERJEE: You know, which is sort of counterintuitive with --

MEMBER BLEY: In one sense, you're better off. In the other, you are real close to the pump not working if you don't --

MEMBER BANERJEE: From an erosion point of view, you are better off going through that zone.

MEMBER SIEBER: Save the pump --

MR. LOBEL: The comment was made, what if you went below the 1.2? You know, that would be --

MEMBER BANERJEE: Which was the issue, right?

MR. LOBEL: But if you go below the 1.2, then you are getting into the other problems with --

MEMBER SIEBER: You save the --

MR. LOBEL: -- cutting down on the margin, so --

MEMBER SIEBER: Save the pump, lose the plant.

MEMBER BROWN: Well, but on your 100 hours, I mean, if you go back to your paper, it is -- the way I read the paragraph in it it is, how long is an open issue still? But you just kind of arbitrarily picked 100 hours as being okay, but you didn't have a basis for saying it was okay.

MR. LOBEL: The basis for --

MEMBER BROWN: I mean, that's the way I read the paragraph.

MR. LOBEL: It is --

MEMBER BROWN: I didn't think it was. I mean, I -- that's not the flavor I got out of that. I may not understand it well enough.

MR. LOBEL: Well, the 100 hours we think is conservative.

MEMBER BROWN: I know, I got that. It's just it wasn't clear from reading this thing that I thought that it --

MEMBER SHACK: That was the one thing everybody agreed on was the 100 hours was conservative. Now, the question is: how far can you go above that?

MEMBER BLEY: Now, one thing you might be able to find something out about, if you talk to plants and other people -- and somebody might have collected this -- I have seen some pumps with very eroded impellers, and they still pump quite well. So some information from people who have a test on a pump not long before they replace the impeller and found, really, a lot of damage to the impeller, you know, I suspect you are far away from any --

MR. LOBEL: The usual rule of thumb is that --

MEMBER SIEBER: They'll pump until the impeller breaks.

MEMBER BLEY: That's what I've seen.

MEMBER SIEBER: And then it locks up.

MEMBER BLEY: And that's a long time.

MEMBER SIEBER: We have circulating water pumps that cavitated, and they would run through a whole cycle.

MR. LOBEL: The usual rule of thumb is the impeller can erode down to like 25 percent of its initial thickness and still have enough strength to keep pumping and --

MEMBER SIEBER: It depends on the pump.

MR. LOBEL: -- it depends on the pump.

MEMBER BANERJEE: The pump won't be as efficient.

MEMBER SIEBER: Well, it's hard to say. As long as the seals are okay, it's probably okay.

MEMBER BANERJEE: You are dissipating more.

MR. LOBEL: You probably don't have anything like a good approach angle anymore when you eroded it that much, but --

MEMBER BANERJEE: But it still pumps.

MEMBER CORRADINI: I just want to make sure -- I guess since we're dwelling on this figure, what you are really telling me is that the pink line should not enter the green zone.

MR. LOBEL: Yes.

MEMBER CORRADINI: Okay.

MEMBER SIEBER: There you go.

MEMBER CORRADINI: That's really the essence of this, right?

MR. LOBEL: Yes. But if it does enter, it shouldn't stay there more than 100 hours.

MEMBER CORRADINI: Got it. Okay.

MEMBER BROWN: But I am going to go back. It says, "An open issue is how long a pump can operate in the maximum cavitation zone without failing and how this cumulative time to failure" --

MEMBER SIEBER: Right out of the --

MEMBER BROWN: "The staff is soliciting information and data to better define the need and length of a time limit for this paper, the time limit of 100 hours." So I don't view that as everybody agreeing that 100 hours is okay. They haven't even -- it very clearly says they have not established a basis for it. So you've got to go back and --

MEMBER SHACK: If you read the pump guy's report, though, he is --

MEMBER POWERS: It seems to me that everything that has been said is that, yes, everybody agrees 100 hours is conservative.

MEMBER BROWN: I don't think so. I don't agree with that. I just wanted to make sure I understood the context. Thank you.

VICE CHAIR ARMIJO: I think we are only halfway through Rich's presentation, and we are out of time, so I think we should --

MR. LOBEL: Oh, okay. Well, let me go

through some of this fast. We have a criterion already that is acceptable to have the available NPSH less than the required NPSH as long as a pump test is run that shows that the pump will still perform its job, and that test -- and the pump consultant we have had helped us come up with some new conditions to add to what we already had in the reg guide for that.

And this would be a test of the pump for whatever time the pump would be -- have available less than required. The pump would be taken apart and examined to make sure that there wasn't any damage or wear to the pump during that time.

I don't see this as anything that really affects us -- I'm sorry, I did it again -- affects us now.

MEMBER BANERJEE: But doesn't this give you a more conservative criteria than we have been using in the past?

MR. LOBEL: I'm sorry. Does what?

MEMBER BANERJEE: Isn't it more conservative to be above the 1.0?

MR. LOBEL: Yes.

MEMBER BANERJEE: So doesn't that -- I mean, doesn't that make a difference to people who are doing evaluations of these --

MR. LOBEL: I'm sorry. Are you talking about this -- the A-1 --

MEMBER BANERJEE: The previous plot.

MR. LOBEL: Oh, the previous one.

MEMBER BANERJEE: Yes.

MEMBER SHACK: 1.6 is higher than 1.0

MEMBER BANERJEE: Yes, a lot higher.

MEMBER RAY: But that was why I was running around trying to find the doggone curves in the first place. But I don't think it's having any effect that I can see on what we talked about the first part of this afternoon at all.

MEMBER SHACK: This is a different concern.

MEMBER BANERJEE: It's a different concern.

MEMBER SHACK: If we assume that the containment integrity is solved, this is still a problem.

MEMBER BANERJEE: Yes.

MEMBER RAY: Yes, but not a problem that we worry about in the same way.

MEMBER SIEBER: Well, you control containment pressure to keep away from this problem.

MEMBER RAY: Well, maybe so, Jack. But if that were the case, then I would be saying, well --

MEMBER BANERJEE: All right. Don't worry about it.

MEMBER RAY: -- we need a way to get the pressure up or the temperature down, which is the same thing, before there is any serious erosion, which is I guess what Charlie is talking about. When is that?

MEMBER BROWN: It is not clear.

MR. LOBEL: Okay.

MEMBER BROWN: And it is variable.

MR. LOBEL: Okay. Let me move on. One of the other issues that we talked about in terms of air or nitrogen coming out of solution is the -- because of the nature of a centrifugal pump, the air tends to accumulate around the shaft and the mechanical seals. And we have to make sure that the seals will be adequately cooled, so that they are not surrounded by just air and fail, although most, if not all, of these types of pumps have throttle or disaster bushings that limit the leakage, but that is not something you want to happen.

So we have been -- so one of the criteria that was proposed was that there be a double seal with an external cooling source. That has a disadvantage of you are adding to the complexity of the system, and discussions we have had with some pump people say that they don't really see this as a problem, because the air may pass through the pump and not accumulate.

And so this is still an issue that we need some clarification on, but it's an issue that needs to be resolved.

MEMBER BANERJEE: But it's a small amount of air, right?

MR. LOBEL: I'm sorry. What?

MEMBER BANERJEE: You're not talking about a lot of air, three percent or something.

MR. LOBEL: No. But it's the accumulation. Kind of the same thing I think with GSI-191 where you don't have a lot of air, but it accumulates.

MEMBER SIEBER: Yes, you trap it.

MR. LOBEL: Yes.

MEMBER SIEBER: Trap it into the suction line.

MEMBER CORRADINI: Yes. It's the same as the debris question. I think that's what he's saying.

MR. LOBEL: Yes.

MEMBER CORRADINI: It is caught and held without being -- without being vented through the system.

MEMBER SIEBER: If you don't have enough flow, you won't push it through. It just stays there.

MR. LOBEL: The pump flow rate -- usually in the safety analysis, a constant value of flow rate is used, and the first bullet says that the flow rate you use for the NPSH analysis has to be greater than equal to the flow rate you use in the safety analysis for core cooling or containment cooling, that that is conservative, but it can't be less than what you are assuming in the safety analysis. That is another kind of obvious statement.

MEMBER BROWN: Why is there no margin placed on that? It just should equal to. Why is that allowed as opposed to some fundamental margin there knowing that you have degradation over time?

MR. LOBEL: Well, you are just talking degradation over time of --

MEMBER BROWN: Whatever. I mean, uncertainties or --

MR. LOBEL: Do you mean --

MEMBER BROWN: -- pump-to-pump variation? I mean, they --

MR. LOBEL: Well, this is something we review. This is something -- this is always a question we ask about what is the pump flow rate.

Typically, it is greater than the safety analysis flow rate. Usually, sometimes a lot greater than the safety analysis flow rate, but it is something we do look at.

Why can it be equal? Usually, there is margin in the safety analysis flow rate. You know, it is one of these things where everybody looks at it from a different point of view, and everybody adds margin, and so --

MEMBER BROWN: I understand that argument. It's just that it's a matter of whether it is actually applied consistently.

MR. LOBEL: It is something that we always look at as part of these reviews.

The second bullet is -- just says if you are going to assume the three percent required NPSH value, or the effective value, you have had a head drop of three percent, and you have to consider that on the pump curve. You have to adjust the flow accordingly. That is kind of obvious, too.

I think we talked about this, Marty talked about this a little bit. Let me just mention that, except for the 100-hour limit due to that green band, we --

MEMBER BROWN: That's interesting. It

says, "No limit is needed."

MR. LOBEL: On the duration. You are not going to --

MEMBER BROWN: But with respect to the 100 hours --

MR. LOBEL: Well, no, this is -- this is for the time you can credit containment accident pressure.

MEMBER BROWN: I understand that. I understand that.

MR. LOBEL: Not the time you are in that band.

MEMBER BROWN: You conclude that you -- there is no need for a limit. Isn't that what that says? Concludes that a limit on duration is not needed.

MR. LOBEL: It is not supported by the risk analysis. And we have thought a long time about this, because it keeps coming up at these meetings. And it just seems that any number we pick is really pretty much an arbitrary number.

And one thing we tried to get away from developing these guidelines is arbitrary numbers. But we didn't want to pick a number and say, "Well, you know, this looks pretty reasonable and okay, but you can't exceed it. And don't ask us why, because we don't have a good reason for it." We are trying to come up with reasons for the numbers we have. And sometimes, like the 100 hours, it's not easy.

CHAIR ABDEL-KHALIK: Going back to the previous figure, is that requirement conservative?

MR. LOBEL: I'm sorry. Is what --

CHAIR ABDEL-KHALIK: Going back to the previous figure where you showed the revised characteristic curve and the same system curve, requiring them to use a lower flow rate in their calculation, is that conservative?

MR. LOBEL: This would be in the safety analysis. They would have to make sure that they considered this effect in the safety analysis.

CHAIR ABDEL-KHALIK: Okay. Versus calculating the --

MR. LOBEL: Yes, I didn't make that clear.

CHAIR ABDEL-KHALIK: -- pressure drop --

MR. LOBEL: Yes.

CHAIR ABDEL-KHALIK: -- in calculating the --

MR. LOBEL: For NPSH.

CHAIR ABDEL-KHALIK: -- available NPSH.

MR. LOBEL: Yes. Okay. Okay. We also

say that the operators have -- that the licensee analysis has to show that the operation of the spray coolers -- the spray or the fan coolers won't cause the accident pressure to be less than what is needed.

The BWR procedures already have a caution that says that, and the BWR calculations assume containment spray for the whole time that containment accident pressure is being credited. So the suppression pool water is being cooled by a heat exchanger and then sprayed into the atmosphere for the whole time that containment pressure is being credited. So for the BWRs, that is pretty well covered.

MEMBER BROWN: They don't turn them off.

MR. LOBEL: They don't assume that they are turned off. The next point that came up at that Subcommittee meeting about turning them off, we have to look into that. I think that is probably a plant-specific --

MEMBER BROWN: Can they be restarted? Is that the --

MR. LOBEL: That's the question, yes. If you turn them off and you need them again, can they be restarted? And I think that is probably a plant-specific question that we will just have to include in the reviews.

MR. DENNIG: If they would propose operator action as part of how they are going to deal with the issue, then that operator action would be reviewed and scrutinized by our human factors people. And these kinds of considerations come into that portion of --

MEMBER BROWN: Well, it is not just human factors. It is a matter of whether you can physically reprime whatever it is. If it was a pump, will it really actually start pumping again?

MR. DENNIG: I understand your point.

MR. LOBEL: There was a case of plant review that I was involved in where they did turn off a pump, and a big part of our review was, could they restart it if they had to, that kind of thing. So it's something that is considered.

Marty talked about the 20 L_a or the 40 L_a. One of the criteria that we are proposing is that there be a leakage rate surveillance where the licensee would first come up with a leakage rate at which containment accident pressure couldn't be maintained anymore, then propose a method to determine that that leakage rate wouldn't be exceeded, and then to propose a limit on the -- if it was exceeded, to exceed -- to propose a time limit, just like most technical specifications -- propose a time limit that you could be in that situation before you had to take a mitigation action, shut down, or some other action.

And so this would be something that we would talk about with the Owners' Group, too, and it would probably either -- it would either have to be a new technical specification, or it would have to be demonstrated that an existing technical specification satisfied this. And for BWRs, that is probably true, that an existing technical specification would cover it.

MEMBER POWERS: Rich, how good is our database on the performance of containments and -- probably not containments, but seals and things like that, under post-accident conditions?

MR. LOBEL: How could we start a database?

MEMBER POWERS: How good is our database?

MR. LOBEL: Oh. How good is our database?

MEMBER POWERS: Yes. What I'm thinking of, of course, is that I have a containment. I am relying on pressure to achieve some net positive suction head. And as the accident -- in a post-accident environment, my containment is subjected to high humidity, high temperatures, elevated pressures, and radiation loads. And I am relying on, in some cases, elastomeric seals, things like that.

And I'm wondering, how good is the database? Is that not going to be limiting?

MR. LOBEL: For the containment or the pump?

MEMBER POWERS: This is for the -- I am worried about the containment, containment isolation.

MR. LOBEL: We talked about that before, and there were two Japanese papers we found that had data on that. And they both were consistent and showed that at the conditions we are talking about, design basis accident type conditions, that it wasn't a problem, that the seals maintained their integrity for a long time. At severe accident conditions, that is -- that was a problem, and the papers were aimed more at severe accident conditions.

I also talked to our -- when this issue came up, I also talked to our environmental qualification people, too. And they say for the kind of conditions we are talking about, design basis conditions, the licensees do have databases, and that is part of our review for environmental qualification, to look at that kind of data and make sure that seals are environmentally qualified for the conditions that they are going to see. So that is something that is addressed pretty routinely in these kind of reviews.

MEMBER POWERS: And we don't see any -- I mean, one of the products of NRC's research for the aging issue was examining the behavior of cables in environments, and it included both temperature and radiation.

MR. LOBEL: Yes.

MEMBER POWERS: And they saw some synergism for the cable insulation, which is somewhat akin to the elastomeric materials used for seals. And they saw some synergism between temperature and radiation there.

MR. LOBEL: Well, these Japanese tests have radiation included also, very high radiation, severe accident level radiation.

MEMBER POWERS: But presumably use Japanese elastomeric materials, and I don't know whether we use the same elastomeric materials or not.

MR. LOBEL: I don't remember for sure what the materials were, but I think they were pretty common sealing materials. Is that -- I mean, we can address that some more. I thought we were --

MEMBER POWERS: Well, it would be certainly interesting to see the environmental qualification that is done for these elastomeric materials for the DBA kinds of conditions, as a counterpose to the Japanese stuff. I think we are familiar with the Japanese papers.

MR. LOBEL: Okay.

MEMBER SHACK: There was some work at Sandia back in the '80s and '90s on those seals. You know, they looked at temperature and pressure primarily. You know, in fact, they aged them. The one shortcoming is probably no long-term irradiation, and then a high temperature.

MEMBER POWERS: And that is a non-trivial shortcoming.

MEMBER SHACK: It's a non-trivial shortcoming.

MEMBER POWERS: Licensees have equipment qualification data that has the correct environment, because it's a non-trivial dose if you're dumping the gap inventory into the containment atmosphere.

MR. LOBEL: Yes. I thought we were done with that. I could have had somebody here to talk about environmental qualification. Maybe next time this issue comes up we'll be sure to have somebody here who can talk about that.

MEMBER POWERS: It would be most

interesting.

MR. LOBEL: Okay. We haven't gotten into available yet, and available NPSH is really the calculation of containment conditions, and the piping losses, and that kind of thing. The staff did our own calculations with the caveats that I talked about before, that we are not trying to duplicate any specific licensee's results.

We use the GOTHIC code, which is more of a best estimate code. Super HEX, the General Electric Hitachi code, is more biased to be conservative. We did realistic, conservative, and Monte Carlo calculations, and at the Subcommittee the question came up about, what did we mean by those three types of calculations?

So let me go on. We did -- oh. We were also asked in the past, not before the Subcommittee meeting, about sensitivity studies. And before then, it was hard to answer that question, because the only data I had was data from licensees, from different reactors, and they only looked at certain variables. So we went back, did our own sensitivity calculations, for one code, for one design of plant, and we summarized the results on this table.

And I won't go through all of this now,

but one of the things we found that was -- quite a few of the variables involved in this seem to have a significant effect. It is not just one or two that stand out.

We did 16 where we -- the first 16 where we varied the parameter by five percent, and then the ones that are colored after that we varied in different ways. The decay heat you varied by adding the two sigma uncertainty, and then not including the two sigma uncertainty. Containment leakage, we increased by a large amount.

We looked at having passive heat sinks and not having passive heat sinks, and we changed the heat transfer coefficients, the condensation heat transfer coefficients, from options in GOTHIC for empirical correlations to more of a heat-mass transfer analogy type of correlation.

MEMBER BANERJEE: Is this a multi-compartment model?

MR. LOBEL: No. It is a single drywell, single wetwell, and the vent system connecting them.

MEMBER BANERJEE: So you changed the containment to heat transfer -- condensation coefficients. Did you change the resistance between these flow paths at all?

MR. LOBEL: No.

MR. SALLMAN: We did not change that.

MEMBER BANERJEE: So the sensitivity to the model parameters were mainly the condensation heat transfer coefficients.

MR. LOBEL: It was --

MEMBER BANERJEE: Closer to any other.

MR. LOBEL: Yes, go ahead.

MR. SALLMAN: The last item, that was 20 -- is that 20? Yes, the last item, 20, is the change in the heat transfer coefficients and the heat sinks. And that has a very small effect I think on that one.

MEMBER RAY: Why 100 percent power instead of 102?

MR. SALLMAN: Excuse me?

MEMBER RAY: Why 100 percent power instead of 102?

MR. SALLMAN: Oh, the base run had 100 percent power, and we are comparing the -- the sensitivity study, we changed that -- different parameters by five percent, just to study that.

MR. LOBEL: I guess it was just a choice that was made.

MEMBER RAY: Well, I just noticed that, you know, we characterize it as conservative inputs except for power. I'm trying to understand why.

MR. SALLMAN: Well, this table does not say "conservative inputs." It is just one base case that we took.

MR. LOBEL: Well, the slide says that.

MR. SALLMAN: Which one is that?

MR. LOBEL: Here. I think it is just the choice of --

MR. SALLMAN: It says 100 percent power instead of 102. Yes.

MR. LOBEL: Okay. Let me --

MEMBER BANERJEE: So the first number is how much -- you have two numbers sometimes in that table.

MR. SALLMAN: Yes.

MEMBER BANERJEE: What are the two numbers?

MR. SALLMAN: These are the -- see this, the NPSH change or the -- is kind of a transient, and so we chose -- the listing here is the maximum and the minimum during the transient.

MEMBER BANERJEE: Okay.

MR. LOBEL: Maximum change and the minimum change.

MR. SALLMAN: Maximum change and the

minimum change.

MEMBER BANERJEE: So the previous conclusion that -- other than the power, the previous conclusion that we had come to in the Subcommittee meeting was for -- apparent conclusion was that the service water temperature was very important. Here you are sort of also -- well, is the initial suppression pool temperature related to the service water temperature in any way, or --

MR. LOBEL: Not directly.

MEMBER BANERJEE: Not directly.

MR. LOBEL: Ahsan may be --

MR. SALLMAN: It looks like they are the same in this calculation.

MEMBER BANERJEE: Because your sensitivity study used the same numbers, right? that is --

MR. WOJCHOUSKI: To answer your question -- this is Alan Wojchouski from Monticello. We are looking at our ultimate heat sink versus our initial suppression pool temperature. There is no correlation between the two of them.

MEMBER BANERJEE: It was only because you selected these by chance, then, 90 and 85.5.

MR. LOBEL: We selected 90 and 85.5 as five percent less.

MEMBER BANERJEE: Five percent less. Yes. What I mean is you did the same exactly for the initial suppression pool temperature --

MR. LOBEL: And the service water, yes.

MEMBER BANERJEE: -- and the service water temperature.

MR. LOBEL: Yes. Yes.

MEMBER BANERJEE: But it was just chance. It is not correlated in any way.

MR. LOBEL: Right.

MEMBER BANERJEE: Okay.

MR. WOJCHOUSKI: Alan Wojchouski again. If they are using it off of Monticello, our ultimate heat sink temperature is 90 degrees, and our tech spec for the maximum suppression pool temperature is also 90 degrees. So that's why we use that in -- deterministic to start with is 90 degrees for service water and 90 degrees for initial temperature. But the correlation between those two is not there.

MEMBER BANERJEE: Okay.

MR. WOJCHOUSKI: Just starting points to be considered.

MR. LOBEL: Okay. The next slide is an example of the calculations we did for NPSH as a function of time for a large break LOCA and --

MEMBER CORRADINI: For some plant.

MR. LOBEL: For some plant unnamed, because it is not exactly any one plant.

We are showing the -- we did a Monte Carlo calculation. We are showing the Monte Carlo results, the realistic results, and the conservative results. And you can see the two horizontal lines at the bottom is the three percent value for an RHR pump and the effective value with our version of the uncertainties multiplied times the three percent value.

MEMBER CORRADINI: So when you say "Monte Carlo," it is those 16 variables you just went through.

MR. LOBEL: I think we used nine for the Monte -- nine that we varied for the Monte Carlo calculation.

MEMBER CORRADINI: By some range of methodology or --

MR. LOBEL: Picked some range, yes, did 59 containment calculations.

MEMBER POWERS: And you assumed that all of those variables were uncorrelated.

MR. LOBEL: Yes.

MEMBER CORRADINI: I guess I was going to ask about the details of it. But you just basically have replicated the bounce. Your black line and your red line are the same. If I misunderstand that -- I think I got it right, right?

MR. LOBEL: Yes. And that was a question last time, and we tried to answer that question.

MEMBER CORRADINI: Let me just make sure I understand what the NPSHA-conservative means. That means you make p-containment equal to p-infinity. You take the ambient pressure or the initial pressure without any accident pressure added in.

MR. SALLMAN: Yes.

MEMBER CORRADINI: Okay. Got it. That's fine. I just wanted to make sure I understood what the black line was.

MR. SALLMAN: The black line is the conservative calculation that is based on the input parameters that are normally used by the licensees for the conservative containment calculation.

MEMBER CORRADINI: But it still has an accident pressure added in.

MR. LOBEL: Yes.

MEMBER CORRADINI: Okay. Excuse me, then. I misunderstood.

MR. LOBEL: Yes.

MEMBER CORRADINI: Okay. Thank you.

MR. LOBEL: There was a question last time about why the Monte Carlo mean was so close to the realistic calculation, and why the minimum was so close to the conservative calculation. And we tried to answer that with this next curve, with this next group of curves, and let me try to explain the conservative one.

We didn't come up with a really great answer, but what we did was we varied -- I think the answer -- let me say what I think the answer is first. The Monte Carlo calculation was done varying nine parameters, and all of the others were made conservative, so they were the same as the conservative calculation.

So when you pick the minimum of the Monte Carlo calculation that has -- you are doing pretty much a conservative calculation with some things varied, and comparing that to another conservative calculation, it is not too surprising that they were close.

But then, the other thing we did to investigate it some more is we varied two variables. And one of them was the -- what we call the K value. It's a measure of the effectiveness of the RHR heat exchanger, and the higher the value, the more heat the heat exchanger is removing. And we changed that value from 147 in the unit -- I think it's -- I won't try to say -- the BTU second per something or other.

MR. SALLMAN: BTU per second degree Fahrenheit.

MR. LOBEL: Fahrenheit. We changed it from 147 to 190, which is a pretty high value. And you can see it didn't make that much difference in terms of NPSH that were within like a foot difference when we made that large change.

We also made a large change to the power. We increased the power by 20 percent of the power decay heat.

MR. SALLMAN: Power. The power decay heat by 20 percent, yes.

MR. LOBEL: And it had even less of an effect, moving the conservative away from the minimum Monte Carlo. So it gives an indication that there is a tendency for those curves to be close to each other, and the best explanation we could come up with is just that the Monte Carlo includes some conservative inputs as well as the conservation calculation input.

Other than that, I'm not sure I have -- I don't have a better explanation.

MR. SALLMAN: But if you look at the

curves in terms of feet, how many feet it is, it is very small. It is like one, one and a half feet, which is half a psi or, you know, it is not a big --

MR. LOBEL: I guess the other thing is that both these calculations are done for the same BWR, so all the geometry is the same, the input conditions are all pretty much the same, except for what we're varying with the Monte Carlo.

So I guess you wouldn't expect the curves to -- from that point of view to be too much different either. We are not doing a Mark I compared to a Mark II or something containment, so --

MEMBER BANERJEE: Well, when you say "conservative, the green one" -- sorry, the black one, your power is 102, as compared to 120 for the conservative --

MR. LOBEL: Right.

MEMBER BANERJEE: -- green, which is -- so that's --

MR. LOBEL: Let me go on. I have a slide that shows conservative, realistic, and Monte Carlo --

MEMBER BANERJEE: All right. Okay.

MR. LOBEL: -- what the inputs were.

MEMBER BANERJEE: Let's do that.

MR. LOBEL: This slide -- that was another question that was asked, what did we mean by conservative, realistic, and Monte Carlo? So we prepared this table that shows the assumptions we made for each of --

MEMBER BANERJEE: Can you just lead us through it? Because there is quite a lot of stuff there. I mean, what are the main points that we should look at here?

MR. LOBEL: Well, okay. Conservative is 102 percent power. We include the measurement uncertainty. Realistic was 100 percent power. Statistical we varied from 100 to 102.

Decay heat, the realistic didn't have the decay heat uncertainty added to it. The conservative adds like two sigma value. Drywell pressure, we made the more realistic higher pressure that the drywell would have, rather than the minimum pressure. The minimum conservative drywell pressure is the same as the atmospheric pressure outside the containment, and so -- for conservatism, and so we made it more what you'd expect to have in thee containment.

The RHR heat exchanger values, the decay value is a little higher for the realistic. The humidity, the last yellow value, we had 100 percent for the conservative. What that does is the more --

you have a total pressure in the containment. The higher the humidity the less non-condensable gas you have in the containment, so the less nitrogen you have in the containment. And so that limits the pressure rise in the containment.

So having 100 percent humidity results in a lower pressure than having 40 percent. And the 40 percent value was a value we got from Browns Ferry. They claimed that 40 percent was the highest humidity they could have in the containment, because any higher value would result in an unidentified leakage tech spec being exceeded. They would be condensing so much liquid, and it is not an identified source that they couldn't have more than a 40 percent humidity without going into a technical specification action statement.

MEMBER BANERJEE: So you'd be worrying about leaks or something, right?

MR. LOBEL: Yes, right. So I guess those are the main points. The mass and energy was pretty much the same. We did our own calculation of mass and energy for this, too. We didn't use -- typically, before now we have used the licensee's results for mass and energy calculations. This time we did our own using GOTHIC.

MEMBER CORRADINI: So the ones you've

highlighted are the ones that are different, right?

MR. LOBEL: Yes.

MEMBER CORRADINI: All the way down the line.

MR. LOBEL: Yes. Yes. And the statistical -- you can see which ones we varied, and which -- the Monte Carlo, which ones we varied and which ones we just use a single value.

MEMBER BANERJEE: For the decay heat -- okay. It is -- I see, it's two sigma and zero sigma. Okay.

MR. LOBEL: Yes. The other comment about this, too, is that even for the realistic we are still making a single failure assumption. We are still only using one train of RHR. So when we say "realistic," that has to be part of the definition of what we are calling -- it isn't really realistic. It is --

MEMBER BANERJEE: You know, but you are required to --

MR. LOBEL: -- licensing basis realistic, yes.

MEMBER BANERJEE: Okay.

MR. LOBEL: And so let me see. So we did -- oh. And then, let's see -- why did I do this? Oh, okay.

MEMBER SHACK: This is looking more like a true mean kind of data.

MR. LOBEL: It turned out that our realistic wasn't all that realistic, and so we came up with another realistic, which, using lack of imagination, we called Realistic-1. And so Realistic-1 is realistic with less conservatism. And so we -- this table shows the changes we made for that.

And this is the difference between -- Realistic-1 is more realistic than what we were calling realistic. And the only reason I'm showing all of this is because this came up in questions last time about what we meant by all these things, so we are just trying to define it a little better.

I don't know if we have made things more complicated in trying to answer the question.

MEMBER SIEBER: You keep doing that you'll get enough margin.

MR. LOBEL: Another question that came up was there was a question about the comparison of the GE calculations with our calculations for the pressure that was required. So we did a calculation. When I say "we," Ahsan did a calculation comparing the GE calculations with our calculations for the conservative and the statistical.

And the GE calculations come from the topical report. We just took points out of the topical report curves, the BWR Owners' Group topical report, and smoothed the curves.

So we have taken the GE calculations from their topical report and just compared it with ours, and you can just see the differences. The differences aren't all that great, and, like I have been saying, we weren't trying to match our calculations to their calculations. So there wasn't any effort made to try to resolve what the differences were between the calculations in the topical report and our calculations.

MEMBER BANERJEE: You said statistical minimum.

MR. LOBEL: It's the 95/95.

MEMBER BANERJEE: So you are doing this 95/95.

MR. LOBEL: Yes, it's the Monte Carlo 95/95.

MEMBER BANERJEE: And the other one is the statistical maximum or what is that? Almost the --

MR. LOBEL: The conservative?

MEMBER BANERJEE: Yes.

MR. LOBEL: Would be the conservative calculation where all the inputs are biased to give a conservative result.

MEMBER BANERJEE: Right. But is that close to the statistical maximum as well?

MR. LOBEL: It's close. Well, it depends which variable you are talking about in terms of required --

MEMBER BANERJEE: Okay. So this is just the wetwell pressure.

MR. LOBEL: Yes, this is the --

MEMBER BANERJEE: Let's talk about the wetwell pressure.

MR. LOBEL: -- pressure. Before we were talking about NPSH.

MEMBER BANERJEE: Right.

MR. LOBEL: You've got to be careful which one you are --

MEMBER BANERJEE: So is the statistical maximum plus your uncertainty, is that close to that blue line, which is called the deterministic or conservative group? What --

MR. LOBEL: We don't know offhand where that would be.

MEMBER BANERJEE: It doesn't matter too

much.

MR. LOBEL: Would the statistical maximum be close to the maximum blue line.

MEMBER BANERJEE: It's the minimum which matters, so it doesn't matter what the --

MR. LOBEL: Yes, I don't know offhand. We could find out.

MEMBER BANERJEE: All right. That's fine. You don't have to do --

MR. LOBEL: We'd probably have to do the calculation.

MEMBER BANERJEE: Curiosity on my part.

MR. LOBEL: Okay. Let me --

MR. SALLMAN: The statistical maximum was not plotted for GE. It was minimum and --

MR. LOBEL: Right.

MR. SALLMAN: Right.

MR. LOBEL: Let me just go through the -- we have talked about all of this already. But in terms of what our guidance is, the first one is we would define an effective required NPSH, which would include uncertainty.

Number two, a conservative analysis should be used to determine the available NPSH, and we -- a change from the Subcommittee, we talked about this and decided that for a couple of reasons previously we have said -- we said conservative or 95/95 lower tolerance limit for NPSH.

And we decided that it is probably good to get rid of the 95/95, because, first of all, probably nobody would ever do that. If you can do one conservative calculation, why would you do 59 calculations? So --

MEMBER BANERJEE: And the difference isn't that much.

MR. LOBEL: And the difference isn't that -- that's the other reason. The difference isn't that much.

And so it still gives the -- having the 95/95, having done the calculation ourselves, it gives us some idea of where the conservative is compared to the 95/95, that there is not really any point including that in the guidance.

A realistic calculation of available NPSH should be conformed -- should be compared --

MEMBER SHACK: Well, I would argue that if in fact you keep the maximum erosion zone thing, then you do need the statistical calculation, because you don't know which history you are on, and you really have to keep all of those histories out of there.

MR. LOBEL: I didn't mention that, because I skipped it over. But I was going to mention, yes, we still need to decide what to do with that. That is another decision that has to be made in connection with that criterion.

MEMBER CORRADINI: But in some sense, though, I mean, what Bill is saying I think is important.

MR. LOBEL: Oh, yes.

MEMBER CORRADINI: If you guys really feel that the limit is something to do with damage versus flow, then you are going to need to look at the range of how you approach that margin. And the range meaning a bunch of calculations.

MR. LOBEL: Yes.

MEMBER CORRADINI: Right? That's what --

MEMBER SHACK: Fifty-nine of them roughly.

(Laughter.)

MEMBER CORRADINI: A bunch.

MR. LOBEL: Okay. And a realistic calculation of available NPSH should be performed to compare it with the available NPSH for --

MEMBER CORRADINI: How long does one of these calculations take?

MR. SALLMAN: Do you mean the code

calculation? In our case, we ran it to 100 hours transient and --

MR. LOBEL: No. I think he means calculation -- computer time.

MR. SALLMAN: Yes, 100 hours transient time took about one and a half hour or two hours. Between one and a half to two hours.

MR. LOBEL: And then, there is the work of putting that into Excel and making the curves and all of that, extracting the data, so that is another --

MR. SALLMAN: That is another --

MR. LOBEL: -- hour.

MR. SALLMAN: -- another two -- couple of hours.

MEMBER SIEBER: If you get paid by the hour, that's the way to go.

MR. SALLMAN: I wish I did.

MR. LOBEL: It took about four days to do the -- for Ahsan to do the Monte Carlo, once things were set up.

MEMBER BANERJEE: Yes. So the 59 runs is not that huge a burden.

MR. LOBEL: It probably would be less for somebody who -- I think the thing can probably be automated, so you wouldn't have to put in the input by hand each time to --

MEMBER SIEBER: You could leave it on over the weekend.

MR. LOBEL: Yes.

MEMBER BANERJEE: Okay. That's good.

MR. LOBEL: Okay. The one we were just talking about, pump operation in the maximum erosion zone, should be limited to 100 hours. The maximum flow rate chosen for the analysis should be greater than the flow rate used for the core and containment cooling analysis.

The mission time of the pump -- we haven't mentioned this before -- should be -- should consider any operation time necessary to maintain stable core and containment cooling. In other words, the pump can't fail right after it used containment accident pressure. You can't use up all of the capabilities of the pump during the accident, because the pump -- the RHR pumps may still be needed to cool the reactor.

Some of these are obvious, and some of these things are already -- a lot of these are already included in our review.

Containment isolation shouldn't be lost due to an Appendix R fire or containment venting, and these are covered by questions we would ask the licensee as part of the review.

Operator action -- we took this out of the guidance, because we feel this goes without saying, that if there is an operator action it will be reviewed by the staff, and the staff will use the established guidance, SRPs and other guidance that the people who do these reviews have for these types of things.

So in that sense, it is not anything that just applies to overpressure. If a licensee comes in and says they are taking credit for any kind of action, that would be something that would be reviewed, and --

MEMBER SHACK: Well, but that may not necessarily look at all the risk implications of that action. I mean, that -- the HRA guys are going to look at this and see if he can do it.

MR. LOBEL: Right. It doesn't look at risk.

MEMBER SHACK: And he is not going to look at all of the other unintended consequences that might be involved here.

MR. LOBEL: Well, but for design basis and the special events type things, you don't assume that the operator is doing the wrong thing or doing something or not doing something he should be doing. So really this review is just to make sure the operator is doing what he should be doing.

The other part of it would be in Marty's type of review. You know, what are the probability that he is going to do the wrong thing, and make things worse?

MEMBER SHACK: Yes. But you make certain assumptions about Marty's world when you come to deciding whether the costs of doing a hardware change are reasonable or not. So you can't say we don't look at Marty's world.

MEMBER RAY: Don't use that word "reasonable." Please.

MEMBER SHACK: Wrong word.

MEMBER RAY: Practical. Impractical.

MEMBER BROWN: What is that? 74K.

MR. LOBEL: Operation for a limited time with available less required is acceptable if it's justified by testing.

MEMBER BROWN: What does "limited" mean?

MR. LOBEL: I'm sorry?

MEMBER BROWN: What does "limited" mean?

MR. LOBEL: Limited time. They would do a test. They would run the test under the exact conditions that they are predicting the pump would run under. Then, they would take the pump apart and look -- inspect the pump and make sure that there is no wear or damage to the pump during that time.

So "limited" means the time that they ran the test for, or more. Actually, it's more the new guidance says you should run it for more than the time you are going to run the test. That was a recommendation from our pump consultant, to not just do it for the exact time, but to do it for a longer time.

MEMBER STETKAR: You mean run the test for --

MR. LOBEL: Run the test for a longer time.

MEMBER STETKAR: Okay.

MR. LOBEL: This is -- the next one, 10, is protecting the seal faces from air accumulation that could lose cooling to the seals. And the last one -- this is -- we get back to practicably, and what we're saying -- we're saying that -- now that for the BWRs we don't think this is necessary, but --

MEMBER BROWN: What, justification is not necessary?

MR. LOBEL: Justification, yes. That the

design can be practicably altered, because of the risk numbers, of the low risk.

MEMBER RAY: Okay. The clarification is because of your conclusions about the risk numbers that --

MR. LOBEL: Yes.

MEMBER RAY: -- you say that.

MR. LOBEL: Yes. And since we have only looked at BWRs of Mark I containments, that is all this applies to.

MEMBER RAY: Well, but have you applied some -- like a backfit criteria? Is that what you are using here?

MR. LOBEL: We haven't really -- we need to talk about where we are going with the operating plants, and we haven't talked about that in any detail yet.

MEMBER SHACK: No. I think Harold is asking, how did you come to this conclusion for the Mark I containments? And that was essentially by applying the backfit cost.

MR. LOBEL: Oh, oh, yes.

VICE CHAIR ARMIJO: No, the backfit cost analysis had nothing to do with it. You just decided the risk is low.

MR. LOBEL: It is just the risk. I don't think --

MEMBER RAY: Let me just hear what he says.

MR. DENNIG: The original -- when the reg guide was modified to put the word "practicable" in, as I understand it from looking at the history of it, the term was meant to be synonymous with feasible, and it envisioned some kind of a safety-benefit versus cost balancing. Is that not the case?

MR. LOBEL: Is that what you're asking what -- back in the reg guide, the word in the reg guide?

MEMBER RAY: No. You said that we had concluded not to do it on BWR Mark Is, because the risk-benefit wasn't justified. And I asked you if by "risk-benefit" you were talking about the backfit that Marty mentioned, or something else. Now, I think I'm hearing it's something else.

MR. LOBEL: Marty, do you want to answer that? Or should I answer that? I think the answer is it was the risk and the cost.

MEMBER RAY: Yes.

MR. LOBEL: That's what we're talking about.

MEMBER RAY: Well, for example, putting in cooling, I'm not sure -- cooling of the suction flow, I don't know what the cost of that is. But if you're saying it's -- the cost that you're talking about is this backfit thing, I just don't think it applies here. And that's why I'm probing on this.

MR. LOBEL: Well, I think that's what it meant.

MEMBER RAY: So if somebody comes in and asks for a change that requires --

MR. LOBEL: That is what it meant.

MEMBER RAY: That is what it meant.

MR. LOBEL: Yes.

MEMBER RAY: So you're saying -- I want to be clear, because if this shows up in the letter I don't want it to be wrong --

MR. LOBEL: Okay.

MEMBER RAY: -- if somebody comes in and asks for a change, and it affects the -- I have to look at the words -- the independence of the barriers, whatever the words were from this earlier thing, and you say, "No, it shouldn't do that," and they say, "Well, but it would cost more than the backfit costs to do that," you would say, "Okay, that's the criteria that we'll use."

MR. DENNIG: Right. But basically we believe we are within the Commission direction and policy on defining "defense-in-depth" and "independence of barriers," that we have not deviated from the guidelines or policy that the Commission has set forth in interpreting that term. And interpreting it some other way would require a discussion with the Commission.

MEMBER RAY: Well, no doubt, but that's maybe what is going to happen. But the point is, the criteria you are referring to now sounds like, oh, you never use the word "backfit," that that's what you're applying. Is that right?

MR. DENNIG: We are applying a safety-benefit cost criterion. And that is one of the bases for a backfit. When we are talking about something for compliance, we do not discuss the cost.

MEMBER RAY: Obviously. I'm trying to make a distinction about a backfit as being separate from a change request, like a power uprate. And you're saying there is no difference between those two things.

MR. LOBEL: No.

MEMBER RAY: No difference between a power uprate request and a backfit.

MR. LOBEL: No, no, that's not what we're saying.

MEMBER RAY: Well, it sure sounds like it.

MR. BAHADUR: Let me see if I can say it in a little simple language that I understand and then go from there. The licensee comes in and applies for a power uprate, and in that licensing action, if the licensee has to make modification in the plants, it is not subject to backfit.

MEMBER RAY: Correct.

MR. BAHADUR: However, if during that review the staff finds out that the licensee has to make some modification to the plant, regardless whether or not a power uprate is to be approved, that particular action will have to go through a backfit analysis, because now the staff is asking licensee to make modifications regardless whether or not the power uprate action needs to be taken.

MEMBER RAY: Does anybody understand what he just said?

MR. LOBEL: Let me try to explain. I think we're getting -- I think we probably shouldn't be talking backfit, but --

MEMBER RAY: I didn't raise that word.

MR. LOBEL: Let me -- if a licensee comes in and -- for a power uprate, or to change strainers, or whatever reason, and he takes credit for containment, he wants to take credit for containment accident pressure, what we're saying is for BWRs with Mark I containments, no further justification is needed than what we presented as a risk analysis.

MEMBER RAY: No, that is sophistry. Look, you just said it was --

MR. LOBEL: Well, if a licensee comes in and wants to -- proposes to make a change, we can review that change. We can ask for information. We can ask for more analysis, anything we think we need as the staff to make a safety justification, if it's related to what the licensee is asking for.

If a licensee comes in and asks to use containment -- and asks to -- asks for use in containment accident pressure, and we want them to contain -- we want them to paint the containment green, that has nothing to do with accident pressure, and that would be a backfit.

MEMBER RAY: But that, again, is a red herring, if you will tolerate my saying so. If someone comes in and asks for a change that affects the independence of barriers --

MR. LOBEL: Yes.

MEMBER RAY: -- and there is a practical way to not affect the independence of barriers, would that alternative to what we proposed not be required because to require it would violate a backfit?

MR. LOBEL: No, of course not.

MEMBER RAY: Okay. Now, given then that there are some other criteria that would apply, other than backfit, okay, what is it?

MR. LOBEL: We are saying the other criterion is that the risk is low enough that it is not necessary to require anything more of the licensee.

MEMBER RAY: Fine. I mean, I can understand that. I think at the end of the day we will want to know better what -- how you judge that.

MEMBER SHACK: Let me see if I can -- what you're having is an alternative between two actions, one which is a safety-benefit if you do without the CAP thing, so you look at the cost-benefit ratio of that approach.

MEMBER RAY: Cost-benefit?

MEMBER SHACK: If you were to make the modification by a hardware change, so you wouldn't have to live with this delta risk that Marty -- that would be a safety-benefit.

MR. LOBEL: If it's something that we propose that the licensee do, then it would be a backfit. We would have to --

MEMBER SHACK: Yes. But just looking at it as a safety beneficial change --

MR. LOBEL: Yes. But the staff is -- if the licensee proposes it, then it is not a backfit for us to --

MEMBER RAY: Wait. There's a premise missing here. The premise is that you don't violate the independence of barriers. If you do, and you have a practical alternative to it, Bill, the issue, then, becomes: what is the criterion by which you make the judgment that they have made? Okay?

And I asked the question: is it the backfit rule? And the answer is no, I think. I don't believe I'm putting words in anybody's mouth.

MR. LOBEL: That's correct.

MEMBER RAY: Okay. So the question is, then, well, what is it? And it is okay not to have an answer to that. You'll know it when you see it I guess. But the point is you can't say, I don't believe -- and, if you do, please tell me, so I can put it in my added comments if I need to -- that you can't say, "I can approve this, if you'll make a practical change," because that way you won't violate the independence of barriers.

MR. DENNIG: Yes.

MEMBER RAY: You are not prohibited from saying that, surely.

MR. LOBEL: No.

MR. DENNIG: We don't believe at this -- we don't believe, Rich, and correct me if I'm wrong, that we don't see these modifications as necessary for compliance.

MR. LOBEL: We are not prohibited from saying that, what you said.

MEMBER BANERJEE: Okay. So somebody comes in and uprates a plant. Let's just take that as an example. They were going to be requiring containment overpressure for an hour or something, a little bit, and now they are going to need it for 17 -- 24 hours. Just pick any number, it doesn't matter. And you do some fiddling with the risk, and you show the risk is small. Are you going to allow that to happen?

MEMBER BROWN: Where is the risk analysis even --

MEMBER RAY: Don't you want to ask if there is an alternative that's practical?

MEMBER CORRADINI: Well, I'm asking, are

they going to require an alternative to keep it at one hour, or are you going to just let them do it?

MEMBER RAY: Well, that's what we don't --

MR. LOBEL: A change like that would be a change -- first of all, what you said, they came in and asked the NRC, which means that there was a change. They licensee decided that they needed NRC's --

MEMBER RAY: That's what we're talking about.

MR. LOBEL: -- approval. they came --

MEMBER BANERJEE: To uprate the plant they need approval, obviously.

MR. LOBEL: Well, okay. I was just taking the part about increasing the time.

MEMBER BANERJEE: I'm talking about an uprate now. Let's be clear.

MR. LOBEL: Well, yes, sure. Then, they --

MEMBER BANERJEE: They are coming in happily, uprating a plant, which is going to make them $250 million a year, or whatever, which we looked at in Vermont Yankee. And now they are saying, "We are going to need three days of overpressure." And we are going to say, "Oh, the risk is really small, and it is not really practical to change the impeller, so we are going to let them do it." Is that it?

MR. LOBEL: That's pretty much what we've been doing, yes.

MEMBER BANERJEE: All right. So as long as it's clear what you want to do.

VICE CHAIR ARMIJO: Yes, and it's -- and the independence of barriers hasn't been violated very much.

MEMBER BANERJEE: Well, whatever it is.

VICE CHAIR ARMIJO: That's the slippery slope you get onto. It's not a hard --

MR. LOBEL: Well, it's a colloquial way of saying what we have been saying, yes.

MEMBER RAY: Yes, but I --

MEMBER BANERJEE: I mean, plain talk here.

MEMBER SIEBER: It's like not being very --

MEMBER RAY: The impracticality or impracticability hasn't even been discussed, as far as I know. All you have looked at is what we reviewed earlier today in terms of what your estimate of the risk-benefit is. But the practicality of avoiding that -- what I keep referring to here as the independence of barriers isn't looked at at all, at least not in this discussion. And BWR Mark Is don't --

MEMBER BANERJEE: All of this stuff is there for a reason.

MEMBER BROWN: They say right here they don't even have to talk to you.

MEMBER BANERJEE: These margins are there for a reason, because we didn't know about sump screen blockage. Today there could be 17 other problems we don't know about, which -- that's why we put these margins in. Right? I mean --

MR. DENNIG: Again, we are not approaching this issue as they are not in compliance, if they require containment accident pressure or need it. We are not treating that as a lack of compliance.

MEMBER RAY: Well, why does that now become the litmus test? At some point, surely, you would say no.

MEMBER SHACK: If it is not a risk-informed application, if it is compliant the regulations and it doesn't meet the criteria in their standard review plan, Appendix D, to bring up things, then --

VICE CHAIR ARMIJO: The point of all of this -- how can you use risk information to justify the change?

MR. DENNIG: We proceeded to provide the risk analysis in response to your concerns with the objective of giving a perspective on the problem, and to satisfy ourselves that we were not involving adequate safety, we were not challenging adequate safety.

MEMBER BROWN: But you are challenging one of the philosophical bases of the degradation -- the independence of barriers.

MR. DENNIG: We are affecting one in the context of --

MEMBER SIEBER: That is an important point. What we are talking about is a policy point as opposed to an engineering point. We don't do policy.

VICE CHAIR ARMIJO: But we can identify that that's the issue.

MEMBER BROWN: Well, they are challenging it, and they are violating it. I mean, effectively, as soon as you do this, you are challenging that -- you are saying, "I'm now challenging, and not requiring, strict independence of barriers."

VICE CHAIR ARMIJO: And the argument is because the risk has changed very little we are not violating it very much, so it's okay.

MEMBER BROWN: It makes me uncomfortable.

VICE CHAIR ARMIJO: Because the time of exposure is small.

MEMBER BROWN: What are you going to do the next time?

MEMBER RAY: The word used is "degraded," not "challenged."

MEMBER BROWN: Okay. Fine. Degraded independence of -- that's fine.

MEMBER SHACK: The point of the regulations are to keep the risk low. Defense-in-depth is one of the ways that you do that. If you can convince yourself that the risk is low, then I think that you don't need the additional defense-in-depth. The question is, is how convincing do you find the argument that the risk is low?

MEMBER BROWN: There is one other point. This is the last barrier. It's the last barrier. It is not a fuel, it is not the vessel in -- it is the last barrier. There are no more.

MEMBER RAY: I think the point has been made that this is a compliance or a non-compliance issue, and it is deemed to not be non-compliant to use containment overpressure.

MEMBER SIEBER: I think you have to go

back to one of Marty's slides that talked about where the independence of barriers sort of fit. And if you look at the whole idea of risk-informing the regulations, that sort of opened the door to tying that together.

Reg Guide 1.174, on the other hand, makes a blanket statement, "Don't make the barriers dependent on one another." I think that what we have is a policy question that the Commission has to decide, rather than a technical question. We can engineer to anything.

MEMBER RAY: I think that's fine, Jack, that they should decide it. I just don't think it has been decided, because if you look over the whole record it is not that clear that this is simply an up or down compliance question.

MEMBER SIEBER: I will grant that.

MEMBER BONACA: I think that it says that there are many lines drawn in the sand around the regulation. One of them is the performance of this system, but there are lines to do with the DNB, with peak pressure in vessel, and so on and so forth.

And, you know, we don't see normally a negotiation in which precedents are being set from application to application of granting relaxation of those limits. That is why I am still scratching my head trying to figure out why in this particular case this negotiation is possible.

Again, yes, the fundamental reason is to leave those barriers independent, but the point is that, why, in this particular case, we are willing to negotiate with the licensee what he needs. And in other cases, in most cases, regulation is not being done, irrespective of risk information. I mean, even if the risk is low, the deterministic frameworks still stand.

MEMBER BANERJEE: We could probably operate a reactor with a few rods --

MEMBER SIEBER: But we --

MEMBER BANERJEE: -- in DNB.

VICE CHAIR ARMIJO: But we put really hard limits, painful, expensive limits, on --

MEMBER SIEBER: You'd operate a reactor without a containment.

MEMBER BANERJEE: I think risk could be shown to be fairly low to operate a few rods in DNB.

MEMBER RAY: We don't need to have everything qualified for seismic.

MEMBER BLEY: Let me ask a risk question, a two-part risk question. Well, one isn't a question.

We know the fire is left out. We don't know how big that is, and we didn't hear any convincing statement of where people estimate it is.

Of the things that were looked at, the post initiator contribution was about a third. That must assume some time. For the pre-initiator, there are arguments about our time of exposure and why that keeps this small. Post-initiator, if we now say, "Well, you could run forever," well, the longer you run, the more that exposure is.

And I haven't heard anything about that, and I -- have you thought about that, or can you say something about it? Especially since we're saying now we don't have any limit; you can run as long as you want, which I think I just heard in the last 20 minutes.

MR. STUTZKE: Yes. Well, in the baseline PRA it was 72 hours for that mission time.

MEMBER BLEY: Okay.

MR. STUTZKE: Okay? And that gives you a certain delta CDF. And it's easy enough to say, "How high could that mission time be before the delta CDF becomes unacceptable?"

For the internal initiating events, if "unacceptable" is defined as 10^{-6} delta CDF, that mission time ends up to be thousands of hours. So it's not a useful --

MEMBER BLEY: Okay. It is that far out.

MR. STUTZKE: -- way to limit the amount of time you would allow someone in containment.

MEMBER BLEY: No, on the seismic risk that you have calculated, we get some over 10^{-6} delta CDF.

MR. STUTZKE: That's right.

MEMBER BLEY: In the two to three range, as I recall.

MR. STUTZKE: That's right.

MEMBER BANERJEE: What is the uncertainty on that delta CDF? Is there a significant uncertainty?

MEMBER STETKAR: Well, and it's also, Marty, the lambda for that post-accident failure is the same lambda that you had applied for pre-accident. It is a fixed lambda based on estimates from normal operating experience. There is no time-related effect. There is no pressure-related effect. There is no --

MR. STUTZKE: That is correct. None of Dr. Powers' concerns.

MEMBER STETKAR: There is no --

MEMBER SHACK: But it would take about a

factor of 100 increase for the 72 hours to get to there.

MEMBER BLEY: I have one other question. Even if, when you're operating in a zone of maximum erosion, the erosion isn't a problem and can't damage the impeller to the point you don't pump. It is also, I assume, the region of maximum vibration. And if that's true, have your pump guys told you how long you can run there, or even thought about it, before you get damage to bearings, wear rings, seals?

MR. LOBEL: It seems -- I believe that it isn't the region of maximum vibration.

MEMBER BLEY: It's not?

MR. LOBEL: That would be farther down, because really you haven't -- you are just generating a lot of bubbles, but the void distribution isn't that bad in the pump.

MEMBER BLEY: It's when it gets to kind of surging that you get the big vibration in there.

MR. LOBEL: Well, the surging is at a lower flow. That was that suction recirculation business. That is at a lower flow, and, yes, that is a very serious thing. And that is another thing that we are going to be looking at soon is suction recirculation.

And it has been addressed in the past by the staff. There was a bulletin that talked about it in terms of doing surveillance testing, but we want to go back and look at it now that it has come up again in terms of accident mitigation.

MEMBER BLEY: I'm just curious, from a practical point of view, have you heard anything about how -- it strikes me it might be a place people would rather make some change than go through some of this kind of testing on their pumps. Have you heard anything about what people are thinking about doing on testing? Because you are putting the pump in a regime that is -- could be --

MEMBER SIEBER: Back in the 1970s, they required the subatmospheric containment people to run the pumps for a test run, measuring all kinds of things like vibration and output pressure and all of that, while the containment was subatmospheric and drawing from the sump and recirculating back to it.

In one case, when they were done with their test and inspected the pump, they ended up redesigning and rebuilding the pump. And so --

MEMBER BLEY: Back to the --

(Laughter.)

MEMBER SIEBER: -- they hadn't done things like that in the past, and the vendor can tell you where the vibration is going to be.

MR. LOBEL: Browns Ferry did a test, an in situ test, of an RHR pump we talked about before with the Committee, and put the pump in cavitation. It was in Unit 3 before they loaded fuel, so they would have -- they had to show that they could operate in cavitation for a certain amount of time. And they did.

And they did have a lot of vibration and noise, but they had vibration sensors on the pump, and they didn't exceed the GE criteria for the vibration on the pump. There was a lot of vibration, but it didn't exceed the pump criteria vibration -- pump vibration criteria.

MEMBER SIEBER: Yes. In the test that I am familiar with, what they found out was it was a vertical drive pump and the bearing locations were wrong to suppress the harmonic vibrations that you were getting because of the cavitation. And one of the changes, besides putting the seals and bearings in, was changing the location of the bearings.

MEMBER RAY: Well, to get -- because we will have to sort this out later, I just want to make sure we are on a fact basis -- I'm not meaning to badger or anything like that. This is an issue of margin, at the end of the day, as far as things that we aren't aware of or that may emerge later.

And I guess the thing I will have to ponder now is this idea that this is a compliance/non-compliance matter, and there still doesn't seem to be any clear criteria for when one is in compliance.

MR. LOBEL: Compliance with?

MEMBER RAY: I just used the word that was used over here. I don't have any idea what it means. I will have to --

(Laughter.)

I'm just trying to repeat it back, so that I don't misconstrue it.

MR. LOBEL: "Compliance" is a word for when you start talking about backfit and regulations and all that. There are several kinds of backfits, and one type of backfit is a compliance backfit where you just conclude that a licensee is not in compliance with the regulations, and something needs to be done to put the licensee in compliance.

And then, there is significant safety increase, which would be a cost-benefit type thing. I think what we are talking about here, we haven't gotten really into compliance with regulations-type thing.

MEMBER RAY: I wouldn't have chosen that word, but I'm just saying that's what I heard said.

MEMBER BROWN: Why wouldn't it be in that -- I'm sorry. Interrupted you.

MEMBER RAY: Again, it's late, I'm only doing this just so that we get clarity around where we stand. And I understand the judgment has been reached that the safety-benefit doesn't warrant doing anything, whether it's practicable or not, for the BWR Mark I. And you guys have explained how you come to that conclusion, so I guess that's all we can ask for.

MEMBER BANERJEE: I want to ask Marty a question. I asked him about the uncertainty, and I think Dennis sort of answered it by saying you bounded it. Is that true, in your estimates, that these numbers are sort of upper bounds?

MR. STUTZKE: It's true. I haven't done any of the actual parametric uncertainty work, because I was busy doing all of the seismic calculations. There are issues about how one would put the appropriate distribution for the parametric uncertainties like that.

The approach I have tried to take is through a series of sensitivity studies show you the answer can't be -- you know, how the answer goes, which direction it would go up and down. So if I have some sort of a tech spec that says they are testing the containment, say, weekly, and that produces a delta CDF of 10^{-8}, I am so far away from an adequate protection concern I don't actually need the uncertainty calculation to inform my decision, because I don't believe it is off by four orders of magnitude.

The problem with the seismic is that now I've got some plants that are right at minus six, or they could be higher, and we know the uncertainty just in the hazard alone is substantial.

MEMBER STETKAR: And you did not -- what did you take? You just took a point for the -- I mean, you had an uncertainty on the fragility, obviously.

MR. STUTZKE: Well, but you used the composite.

MEMBER STETKAR: Composite mean --

MR. STUTZKE: It's the convolution of the mean seismic hazard and the mean fragility curve.

MEMBER STETKAR: Okay. So you didn't do a -- okay.

MR. STUTZKE: So, yes. No, it's -- and I don't pretend it's a full-blown PRA treatment of the --

MEMBER STETKAR: So you didn't do a full convolution with the slices over the range of accelerations.

MR. STUTZKE: No.

MEMBER BANERJEE: So what should we conclude from this, that your estimates take into account the various uncertainties?

MR. STUTZKE: The other thing I would leave you with is when you compare risk results to guidelines, we are supposed to compare it with the mean result, not the 95th percentile, but the mean. And we are supposed to be knowledgeable of the uncertainty, and we have a whole NUREG, NUREG-1855, that tells us what to do about that.

But still, at the end of the day, it's a judgment. Are you comfortable with the amount of uncertainty in the PRA? And, if you're not, what other compensatory measures should be imposed to mitigate that until you become comfortable with it?

MEMBER BANERJEE: So are you sort of saying that you are comfortable with the uncertainty in the PRA?

MR. STUTZKE: I am comfortable with it now.

MEMBER BANERJEE: And that bounds all of the uncertainties by --

MR. STUTZKE: I would say that it balances all of the uncertainties. Yes, I think the answer --

MEMBER BANERJEE: I am trying to understand whether I should feel comfortable about it without knowing anything about it.

MR. STUTZKE: I don't think I want to go there at 5:30.

MEMBER BANERJEE: Well, but --

MR. STUTZKE: Yes, I appreciate your --

MEMBER BANERJEE: Okay. Thank you.

MEMBER SHACK: Do we have any more questions for the staff? I think, you know, obviously, we need to have a fair amount of discussion among ourselves that may run for quite a while, so we might want to get to it.

If not, thank the staff for some excellent presentations today. I think it was -- you made a heroic effort to address a number of the issues that we raised at the Subcommittee meeting. You addressed them; whether they're resolved is a different question, but address is the best you can do.

Back to you.

CHAIR ABDEL-KHALIK: Thank you. Thank

you. At this time, we will take a break for 15 minutes. We will reconvene at 5:45, and we are off the record at this time. We will reconvene to look at -- start the report preparation.

(Whereupon, at 5:25 p.m., the proceedings in the foregoing matter went off the record.)

Updating the Standard Review Plan for Dry Storage Systems (NUREG-1536)

Briefing for the ACRS Full Committee

Division of Spent Fuel Storage and Transportation
Office Of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission

- May 6, 2010 -

Opening Remarks

Raymond Lorson, Deputy Director
Meraj Rahimi, Acting TCB Branch Chief
Technical Review Directorate
Division of Spent Fuel Storage and Transportation (SFST)

Purpose

- Brief the ACRS on the update to the Standard Review Plan (SRP) for Spent Fuel Dry Storage Systems at a General License Facility (NUREG-1536)

- Obtain ACRS comments and concurrence to publish

Briefed Subcommittee on February 17, and April 21, 2010

- Revision to NUREG-1536, Jan 1997
- Dry Cask Storage Background
  - Division of Spent Fuel Storage and Transportation
  - Typical Dry Cask Storage Operations
  - Regulatory Basis and Design Basis
- Std. Review Plan (SRP) Update Project
  - Overall Project Approach
  - Prioritization Method
  - Key Revisions to SRP per Chapter
  - Key Stakeholder Comments per Chapter

Incorporated ACRS Subcommittee Comments to Improve the SRP

- Replaced “Risk Informed” with Prioritized
- Identified Polymeric Neutron Shielding Materials as Important-To-Safety
- Changed prioritization method to reevaluate ‘Low’ or ‘Very Low’ ratings for Question #2
- Changed ‘catastrophic’ consequence to significant consequence from rating criteria of prioritization method
- Clarified reason for burnup measurements associated with granting burnup credit

Today's Presentation

- SRP Update Project & Public Comments (Ron Parkhill)
- Prioritization Methodology (Dennis Damon/Ron Parkhill)
- Radiation Protection (Elizabeth Thompson)
- Spent Fuel Oxidation (Ron Parkhill)
- Burnup Credit Measurements (Meraj Rahimi)

SRP Update Project

- SRP (NUREG 1536) issued 13 years ago (1/97)
- The update project started 4 years ago to
  – Incorporate applicable interim staff guidance documents & other necessary changes
  – Prioritize the review procedures section of each SRP chapter to better utilize staff resources
  – Develop a new materials chapter
  – Enhance knowledge transfer

Public Comments

- Only received comments from industry (NEI 192 and NAC 30 - mostly duplicated)
- Listed & Dispositioned in Appendix D to SRP
- Staff agreement on over 60% of the comments
- Resulted in better SRP

Prioritization Methodology

Dennis Damon, Sr. Level Advisor for Risk Assessment, FCSS

Ron Parkhill, Sr. Mechanical Engineer, SFST

Prioritization Methodology - focuses staff resources

- Focuses staff resources by assigning high, medium or low to items in the Review Procedures
- Standard Review Plan Chapter Structure
  - Review Objective
  - Areas of Review
  - Regulatory Requirements
  - Acceptance Criteria
  - Review Procedures (Prioritized)
  - Evaluation Findings

Prioritization Methodology

(1) Likelihood that requirement will not be met	**VH**=4, likely to occur, P>.5 **H**=3, Probably will occur, 0.1< P < 0.5 **M**=2, May occur, 0.03< P< 0.1 **L**=1, Unlikely to occur, 0.01<P< 0.03 **VL**=0, Occurrence improbable P< 0.01
(2) Likelihood that staff review will find the discrepancy	Same as (1)
(3) Risk if requirement not met	**H**=3, Likely to occur or significant consequences, >10^{-3}/yr or 25 rem to worker or 1 rem to public **M**=2, may occur or moderate consequences, <10^{-3}/yr but >10^{-5}/yr or 5-25 rem to worker or 0.1-1 rem to public **L**=1, Occurrence improbable or marginal consequences, < 10^{-5}/yr or less than 10CFR 20 dose limits for workers & public
(4) Add scores from (1), (2) & (3) to get combined Risk score	**High** is 9 to 11 **Medium** is 6 to 8 **Low** is 1 to 5

Prioritization Methodology (Cont'd.)

(5) Determine Defense in Depth- a review procedure impacts DinD if it provides a back up to the first line of defense (e.g. confinement is back up to cladding integrity)	If failure to perform a review procedure could impact DinD (assuming front line safety measure has failed) and has -a low, medium or high likelihood and/or consequence, then the item should be a low, medium or high, respectively -Same as (3) for low, medium or high Note most SRP review procedure items don't have DinD
(6) Determine which controls (or is more important) DinD (Step 5) or Risk (Step 4)	Assign controlling rating from DinD or Risk

Summary of Prioritization Results

Chapter	HIGH	MEDIUM	LOW	Total
1) General Info	----	4	----	4
2) Principle Design Criteria	----	4	1	5
3) Structural	6	13	7	26
4) Thermal	6	7	5	18
5) Confinement	----	5	2	7
6) Shielding	5	3	----	8
7) Criticality	11	3	1	15
8) Materials	7	13	7	27
9) Operating Procedures	2	5	4	11
10) Acceptance tests and Maintenance Program	5	3	7	15
11) Radiation Protection	----	4	----	4
12) Accident Analyses	----	1	----	1
13) Technical Specifications and Operational Controls & Limits	1	----	----	1
14) Quality Assurance	1	----	----	1
TOTALS	**44**	**65**	**34**	**143**

Radiation Protection in Dry Storage System Licensing and Operations

Elizabeth Thompson, CHP
Sr. Health Physicist, SFST

Radiation Protection

- SRP Revision
  - Incorporated ISGs
  - Few other changes

- Typical Doses
  - Per cask loaded
  - Per campaign
  - Trends

Fuel Oxidation

Dr. Robert Einziger,

Sr. Materials Engineer, SFST

Ron Parkhill,

Sr. Mechanical Engineer, SFST

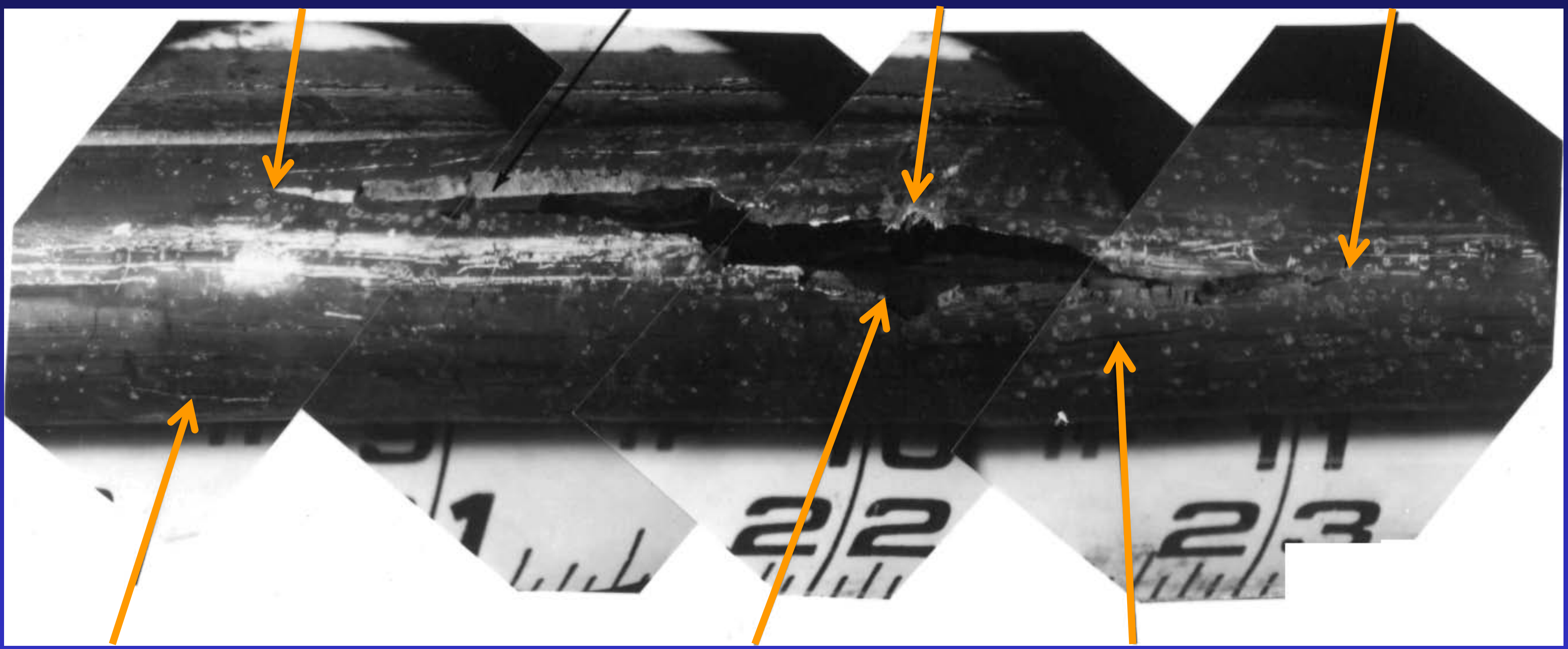
Fuel Oxidation

- Fuel Integrity
  - Clad Splitting (unzipping) when spent fuel is exposed to air
  - >30% expansion upon oxidation of UO_2 to U_3O_8
- Confinement of Radioactive Material
  - Open grain boundaries in the fuel can release fission products
- To date all casks have been licensed for storage in an inert gas.

Fuel Oxidation

“Effects of an Oxidizing Atmosphere in a Spent Fuel Packaging Facility”,
EPRI NP-4524 R.E. Einziger, Sept 1991.

Fuel Oxidation



“The Performance of Defected Spent LWR Fuel Rods in Inert and Dry Air Storage Atmospheres”, Nuclear Engineering and Design, C. S. Olsen, Nov 1985.

Burnup Credit Measurements

Meraj Rahimi,
Acting TCB Branch Chief
Technical Review Directorate, SFST

Burnup Credit Measurements

- NEI Comment #162 - delete performing measurements to confirm assembly burnup values

  -Changed Response to clarify SRP that a confirmatory measurement, which would be based on reactor records, is needed to prevent misloading of assemblies that do not meet the loading criteria for burnup credit

Summary

- Incorporated several ISG’s
- Updated to reflect current review practices
- Added new materials chapter
- Prioritized the review procedures
- Resolved public (industry) comments
- Improved safety focus of certification reviews

Path Forward

- Issue Final SRP Revision 1 (June)
- Continue Work on SRP for Storage Facilities (NUREG-1567)

USE OF CONTAINMENT ACCIDENT PRESSURE IN DETERMINING THE AVAILABLE NET POSITIVE SUCTION HEAD (NPSH) OF EMERGENCY CORE COOLING SYSTEM AND CONTAINMENT HEAT REMOVAL PUMPS

May 6, 2010

ACRS

Sher Bahadur

Deputy Director,

Division of Safety Systems

NRR

Introduction-1

- Recent staff/ACRS discussions of containment accident pressure:
  - November 15-16, 2005 Vermont Yankee EPU (Power Uprate Subcommittee)
  - December 7, 2005 Vermont Yankee EPU
  - February 1, 2007 Browns Ferry Unit 1 5% power uprate
  - December 4, 2008 staff white paper
  - March 18, 2009, ACRS letter with recommendations
  - Suspended review of use of containment accident pressure in Browns Ferry (September 18, 2009) and Monticello (October 1, 2009) EPU license amendment requests
  - April 23, 2010 draft staff guidance (Power Uprate Subcommittee)

Introduction-2

- Staff study of use of containment accident pressure in response to ACRS March 18, 2009, letter
- Major work accomplished:
  - Review of BWROG topical report on use of containment accident pressure
  - Consulted with experts in cavitation, NPSH and pump hydraulics
  - Performed calculations to study sensitivities and margins
  - Performed risk assessment
  - Prepared draft guidance on use of containment accident pressure based on the above work
- April 14, 2010 meeting with BWROG

Introduction-3

- Presentations:
  - Risk Aspects
  - Containment Integrity
  - Draft Guidelines
- Staff requests letter
- Future Actions
  - Finalize guidance with BWROG and PWROG and other stakeholders
  - Resume two EPU reviews
  - Document guidance

Risk Evaluation of Using Containment Pressure to Prevent ECCS Pump Cavitation

Marty Stutzke
Eli Goldfeiz
Anders Gilbertson

Division of Risk Analysis
Office of Nuclear Regulatory Research

May 2010

Outline

- Overview
- Technical Approach
  - Preliminaries
  - Leak Probabilities
    - Pre-initiator
    - Upon-initiator
    - Post-initiator
  - Operator Actions
  - Seismic Risk Evaluation
- Risk Insights

Technical Approach

- Purpose: To estimate the increase in core-damage frequency (CDF) that results from relying upon containment accident pressure (CAP) to prevent ECCS pump cavitation.
- General approach:
  - Internal Events
    - Modify Standardized Plant Analysis of Risk (SPAR) models
    - Addresses all internal initiating events (LOCAs and transients)
    - Browns Ferry and Monticello
    - Assumes CAP credit is needed whenever the CS or RHR pumps are taking suction on the suppression pool
  - Seismic Events
    - Simplified method being used in GI-199
    - Added seismically induced loss of containment integrity (HCLPF = 0.3g)
    - Assumes loss of containment integrity directly causes core damage for all accident sequences
  - Internal Fires
    - Not assessed due to lack of detailed cable routing information to assess the impact on fire on containment integrity
    - Deterministic guidance developed

The Definition of "Loss of Containment Integrity"

- The event "loss of containment integrity" means that the containment is leaking enough to prevent adequate NPSH.
- The leak size needed to prevent adequate NPSH is plant-specific, and should be determined through containment thermal-hydraulic analyses (e.g., GOTHIC, MELCOR).
- Leak sizes used in previous license-performed risk evaluations:
  - Vermont Yankee EPU:
    - 27 La (calculated using 10 CFR 50 Appendix K requirements)
    - 60 La (using more realistic assumptions)
  - Browns Ferry EPU: 35 La (engineering judgment)
- Assumed 20 La in this analysis.

Three Timeframes Considered

- Pre-initiator: Containment may be leaking before an initiating event occurs.
- Upon-initiator: Containment may fail to isolate when an initiating event occurs.
- Post-initiator: Containment may start to leak after the initiating event occurs.

Pre-Initiator Leak Probability

- Previous risk evaluations used a pre-initiator (pre-existing leak) probability that only depended on the size of containment leakage.
  - Vermont Yankee EPU: 2.47×10^{-4} (from EPRI TR 1009325)
  - Browns Ferry: 9.86×10^{-4} (from EPRI TR 1009325)
- However, the probability of a pre-initiator containment leak should also depend on how the containment integrity is tested:
  - How often the test is performed, for example:
    - Integrated leak rate tests (ILRTs)
    - Oxygen concentration monitoring in BWR Mark I containments
  - Test efficiency (how good is the test at detecting leaks of the size needed to preclude adequate NPSH)
- The staff developed a semi-Markov model to represent the impact of containment integrity testing on the pre-initiator leak probability.

Technical Specification

CONDITION	REQUIRED ACTION	COMPLETION TIME
Containment leakage at or above [20] La	Reduce containment leakage below [20] La	T_{ST} [24h]
Required Action and Associated Completion Time not met	Shutdown plant	T_{SD} [8h]

SURVEILLANCE	FREQUENCY
Verify containment leakage less than [20] La	T_I [7 days]

Patterned after BWR/4 Standard Technical Specification 3.6.3.2, "Primary Containment Oxygen Concentration"

Parameters that Determine the Pre-Initiator Leak Probability

- Containment leakage failure rate, λ
- Mean time to repair, τ
- Surveillance test interval, T_I
- TS-allowed repair duration while at-power, T_{ST}
- TS-mandated shutdown time, T_{SD}
- Test sensitivity (probability of a Type II error), β, δ, and ε

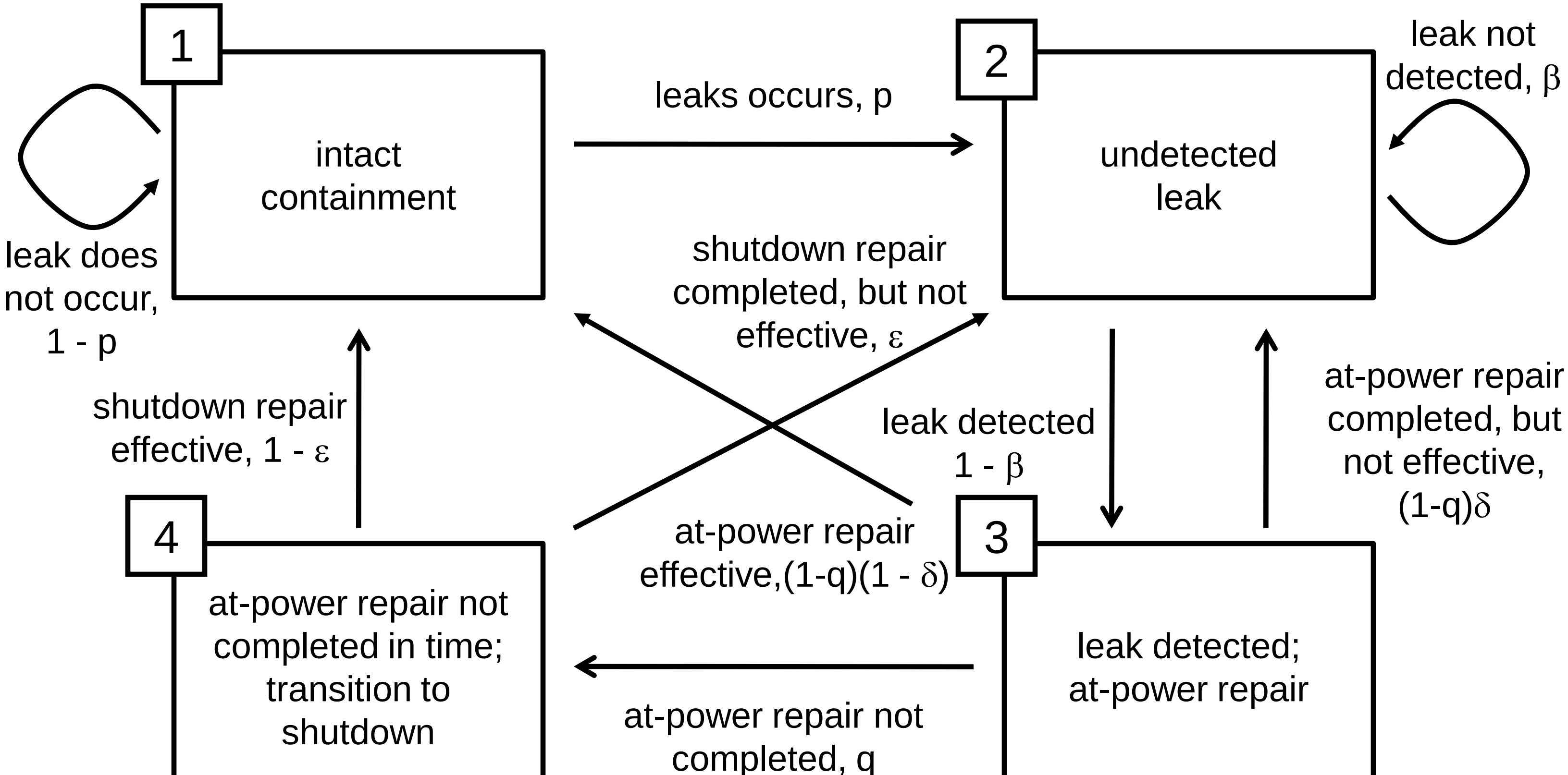
Test Confusion Matrix

(Statistical Hypothesis Testing)

		Actual Containment Condition	
		Leak (true)	Intact (false)
Test Result	Leak (positive)	**true positive** $Pr\{T_P \mid C_T\} = 1 - \beta$ $= \text{sensitivity}$	**false positive** (Type I error) $Pr\{T_P \mid C_F\} = \alpha$
	Intact (negative)	**false negative** (Type II error) $Pr\{T_N \mid C_T\} = \beta$	**true negative** $Pr\{T_N \mid C_F\} = 1 - \alpha$ $= \text{specificity}$

- False negatives are important to plant safety.
- False positives are important to plant operations.

Semi-Markov Model



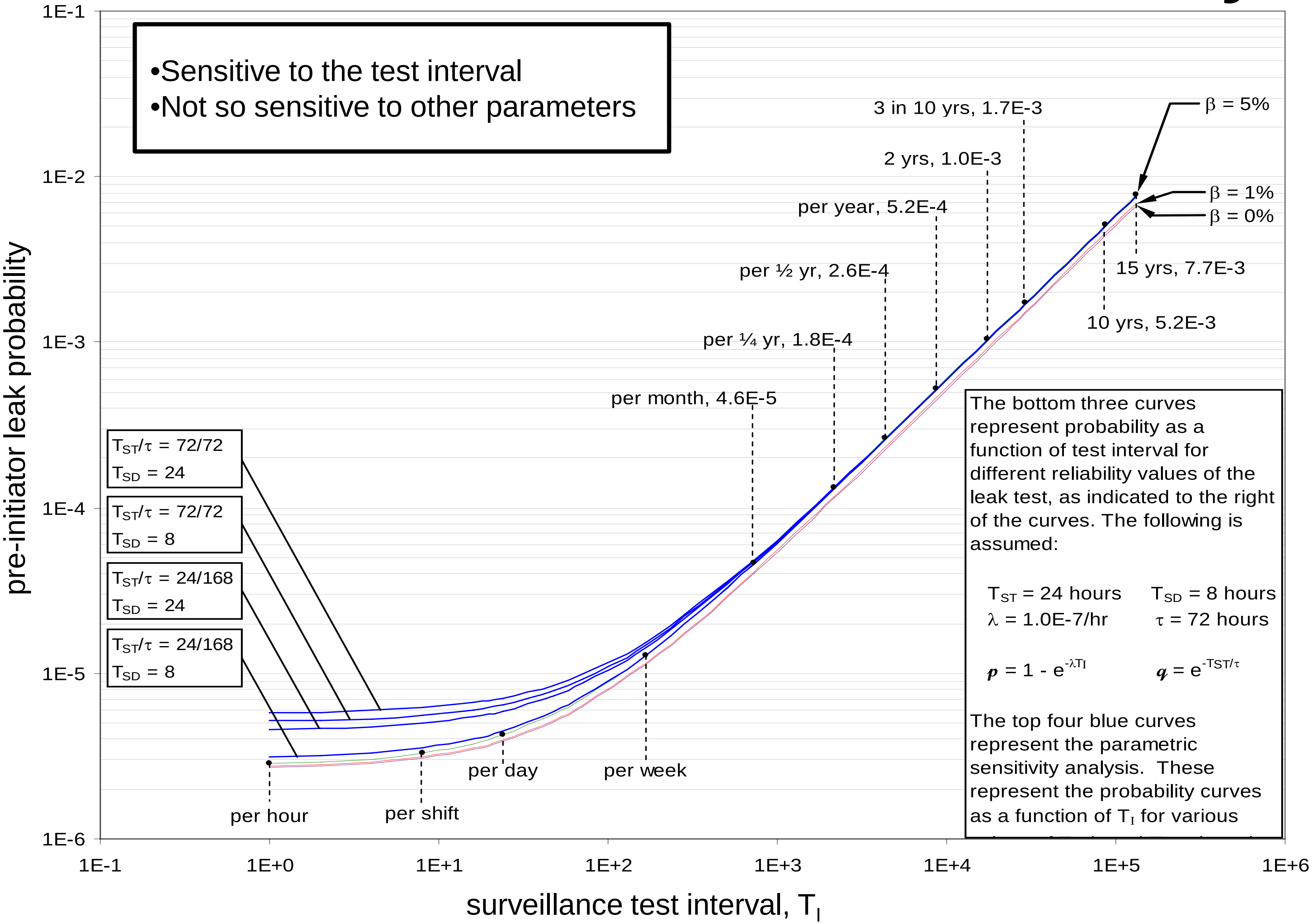
Pr{pre-initiator leak} = long-run fraction of time that the system is in States 2, 3 and 4

Containment Leakage Reliability Parameters

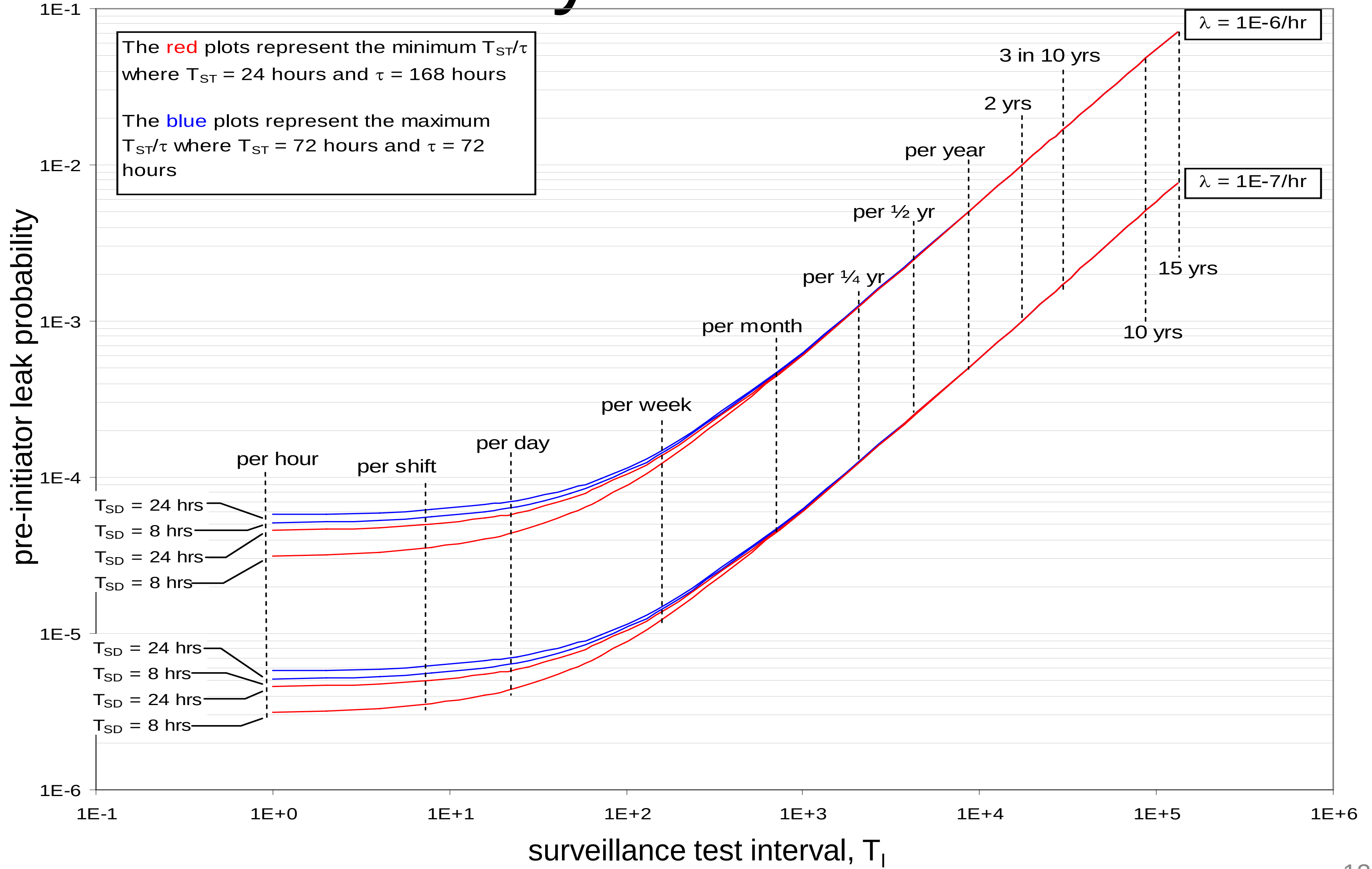
$$\lambda(20\,L_a) = \frac{\Pr\{\text{leak} \geq 20\,L_a \,|\, \text{leak})}{\Pr\{\text{leak} \geq 1\,L_a \,|\, \text{leak})} \times \lambda(1\,L_a) = 1 \times 10^{-7}\,/\text{h}$$

- λ(1 La) = 1.1E-2/RY = 1.3E-6/hour from NUREG-0933, “Resolution of Generic Issues,” Section 1 – TMI Action Plan Items, Item II.E.4, “Containment Integrity”
- Leak size distributions:
  - Pr{leak ≥ 20 L_a | leak exists}= 2E-3
  - Pr{leak ≥ 1 L_a | leak exists}= 3E-2
  - Source: Table D-1 of EPRI, “Risk Impact Assessment of Extended Integrated Leak Rate Testing Intervals,” Report No. 1009325, Rev. 1, October 2005 (ADAMS Accession No. ML053550424).
- Mean time to repair, τ = 72 hours (NUREG-0933)

Pre-Initiator Leak Probability



Pre-Initiator Leak Probability Sensitivity to Failure Rate



Containment Isolation

- During routine power operations, there are no pathways between the containment and the atmosphere.
  – Pathways exist during inerting (24h after plant startup) and deinerting (24 h prior to plant shutdown.)
- As a result, only necessary to model failure of the containment isolation system to close on demand when these pathways exist:

$$\Pr\{\text{upon-initiator leak}\} = \frac{2 \times 24\text{h}}{24\text{m}} \times \frac{1\text{m}}{730\text{h}} \times 10^{-3} = 3 \times 10^{-6}$$

- Different approach than previous licensee-performed risk evaluations, which assumed that containment isolation is always required.

Containment Isolation (Con't.)

- Following the occurrence of a LOCA (LLOCA, MLOCA, or SLOCA), failure to close the MSIVs introduces a pathway between the containment and the atmosphere.
- The probability that all MSIVS fail to close on demand is about 10^{-4} (including independent and common-cause failures).
- This pathway is a very small contribution to the change in core-damage frequency since LOCAs frequencies are relatively small.

Post-Initiator Leak Probability

- Used 72h mission time to account for the period that containment accident pressure is needed to provide adequate NPSH.

$$\Pr\{\text{post}-\text{initiator leak}\} = 1 - e^{-\lambda T} \approx \lambda T$$

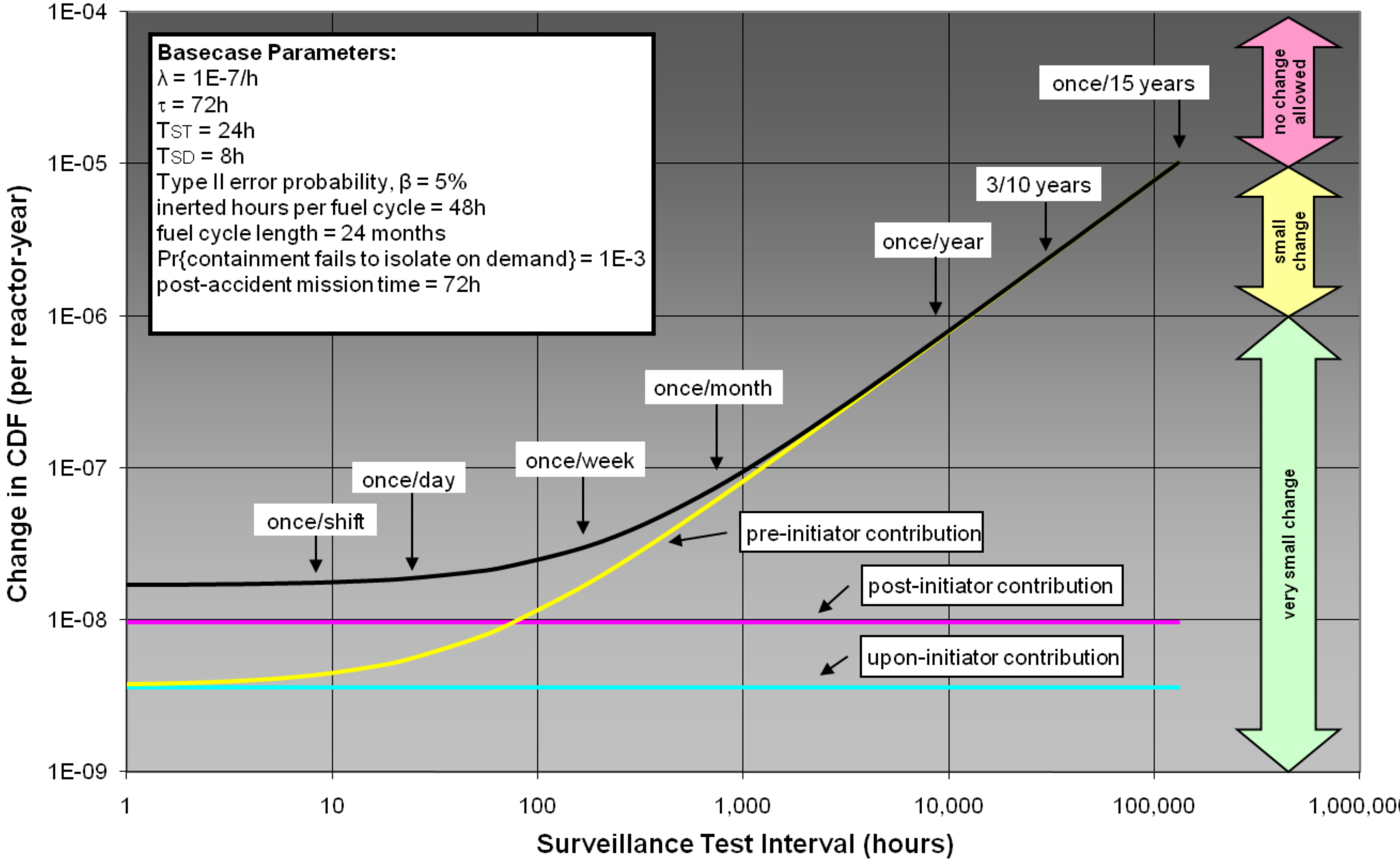
$$= (1 \times 10^{-7}/\text{h})(72\text{h}) = 7 \times 10^{-6}$$

The mission time is the only parameter in the model that pertains to the duration of the CAP credit

Operator Actions

- Current T/H analysis indicates that no operator actions are needed to implement the CAP credit (e.g., tripping the drywell coolers).
- Readily included in a risk evaluation, if needed:
  - Existing HRA methods adequate to estimate the human error probability (HEP).
  - Need to consider potential dependencies with other operator actions.
- May be a significant contribution to risk:
  - Human error probability >> pre-initiator, upon-initiator, and post-initiator leak probabilities.

Browns Ferry CAP Credit - Internal Events



Seismic Risk Evaluation

- Simplified method being used in GI-199:
  - Integration of the mean seismic hazard curve with the mean plant-level fragility curve (not a seismic PRA).
    - Hard rock seismic hazard: USGS 2008
    - Site-specific soil amplification factors: EPRI/SOG 1989
    - Plant-level fragility: IPEEE information or license renewal SAMA analysis (SPRA or SMA)
  - Added seismically induced loss of containment integrity:
    - HCLPF = 0.3g and β_C = 0.4
    - Assumes loss of containment integrity directly causes core damage for all accident sequences
- Evaluated all BWRs with Mark I containments.

Increase in Seismic Core-Damage Frequency Due to the CAP Credit

Plant Name	Docket Number	SCDF no CAP credit needed	SCDF CAP credit needed	ΔSCDF due to CAP credit
Browns Ferry 1	05000259	3.7E-06	5.7E-06	2.0E-06
Browns Ferry 2	05000260	5.4E-06	7.0E-06	1.6E-06
Browns Ferry 3	05000296	5.4E-06	7.0E-06	1.6E-06
Brunswick 1	05000325	1.5E-05	2.5E-05	9.8E-06
Brunswick 2	05000324	1.5E-05	2.5E-05	9.8E-06
Cooper	05000298	7.0E-06	1.1E-05	3.9E-06
Dresden 2	05000237	1.2E-05	1.5E-05	3.1E-06
Dresden 3	05000249	1.2E-05	1.5E-05	3.1E-06
Duane Arnold	05000331	3.8E-06	6.0E-06	2.2E-06
Fermi 2	05000341	4.2E-06	6.0E-06	1.8E-06
FitzPatrick	05000333	6.1E-06	6.9E-06	8.3E-07
Hatch 1	05000321	2.5E-06	3.8E-06	1.3E-06
Hatch 2	05000366	2.5E-06	3.8E-06	1.3E-06
Hope Creek 1	05000354	2.8E-06	8.9E-06	6.1E-06
Monticello	05000263	1.9E-05	2.0E-05	1.9E-07
Nine Mile Point 1	05000220	4.2E-06	5.4E-06	1.2E-06
Oyster Creek	05000219	1.4E-05	1.6E-05	2.4E-06
Peach Bottom 2	05000277	2.4E-05	2.7E-05	2.3E-06
Peach Bottom 3	05000278	2.4E-05	2.7E-05	2.3E-06
Pilgrim 1	05000293	6.9E-05	7.5E-05	5.9E-06
Quad Cities 1	05000254	2.7E-05	2.7E-05	5.3E-08
Quad Cities 2	05000265	2.7E-05	2.7E-05	5.3E-08
Vermont Yankee	05000271	8.1E-06	9.9E-06	1.8E-06

All plants meet the numerical risk acceptance guidelines in RG 1.174

Risk Insights

- There is only one minimal cut set where the loss of containment integrity leads directly to core damage (large LOCA).
- The increase in internal event CDF is very small ($<10^{-6}$/y, as defined in RG 1.174) when testing is conducted at least once/year (assuming a leak failure rate of 10^{-7}/h).
- The increase in seismic CDF meets the numerical risk acceptance guidelines in RG 1.174 for all plants.
- Contributions to containment leakage probability:
  - Pre-initiator (basecase): 55.9%
  - Post-initiator: 32.1%
  - Upon-initiator: 12.0%

Risk Insights (Con't)

- Importance measures for loss of containment integrity:
  - Fussell-Vesely (FV): 0.017
  - Risk achievement worth (RAW): 750
  - The loss of containment integrity is a "significant basic event," as defined in the ASME/ANS PRA Standard (FV > 0.005 and/or RAW > 2), over a wide range of model parameters.
- Sensitivity studies indicate that the pre-initiator contribution to the containment leakage probability mainly depends on:
  - The containment leakage failure rate
  - The surveillance test interval

Breakdown of Internal Event CDF Contributions

Initiating Event	No CAP Credit		With CAP Credit		Change in CDF	
	CDF	Percent	CDF	Percent	CDF	Percent
General Transient	3.4E-08	1.9%	3.4E-08	1.9%	2.9E-10	0.9%
Small LOCA	1.1E-09	0.1%	1.1E-09	0.1%	2.5E-12	0.2%
Steam Line Break Outside Containment	6.4E-08	3.7%	6.4E-08	3.6%	1.7E-11	0.0%
Medium LOCA	6.5E-08	3.8%	6.8E-08	3.8%	2.3E-09	3.6%
Loss of Service Water	9.1E-09	0.5%	1.8E-08	1.0%	9.2E-09	101.2%
Loss of Plant Control Air	7.1E-09	0.4%	1.1E-08	0.6%	3.5E-09	49.6%
Loss of Offsite Power	1.4E-06	81.4%	1.4E-06	80.2%	3.5E-09	0.2%
Loss of Main Feedwater	2.9E-08	1.7%	2.9E-08	1.7%	5.0E-11	0.2%
Large LOCA	7.8E-09	0.4%	8.0E-09	0.5%	2.3E-10	2.9%
Inadvertent Open Relief Valve	1.4E-08	0.8%	1.6E-08	0.9%	1.6E-09	11.8%
Loss of Condenser Heat Sink	9.3E-08	5.3%	1.0E-07	5.8%	9.4E-09	10.1%
Total	1.7E-06		1.8E-06		3.0E-08	1.7%

No significant change in the plant risk profile

Conclusions

- Major risk insights:
  - The loss of containment integrity is a “significant basic event,” as defined in the ASME/ANS PRA Standard, over a wide range of model parameters.
  - The increase in internal event CDF can be made very small ($<10^{-6}$/y, as defined in RG 1.174) with adequate testing of containment integrity.
  - The increase in seismic CDF meets the numerical risk acceptance guidelines in RG 1.174 for all plants.
  - Operator actions, if needed to implement a CAP credit, may be significant risk contributors.
- The increases in core-damage frequencies due to CAP credits are small and consistent with the intent of the Commission’s Safety Goal Policy Statement.

Backup Viewgraphs

Semi-Markov Processes

- System is in one of a number of discrete states.
- The probability that the system transitions to another state depends only on its current state:
  - Transitions are independent of the system's past history.
  - This characteristic is called the "Markovian property."
- The time that the system waits in a given state is random with an arbitrary probability distribution:
  - In general, each state has its own waiting time distribution.
  - Special cases:
    - Markov chain – all waiting times are fixed and equal.
    - Continuous time Markov process – all waiting times are exponentially distributed.

Average State Durations

M_1	$T_I\left(1-\dfrac{p}{2}\right)$
M_2	$\dfrac{T_I}{2}(1+\beta)$
M_3	$qT_{ST}+(1-q)\dfrac{\tau-(\tau+T_{ST})\exp(-T_{ST}/\tau)}{1-\exp(-T_{ST}/\tau)}$
M_4	T_{SD}

Semi-Markov Model Solution

$p = 1 - \exp(-\lambda T_I)$ Probability of leak over interval T_I

$q = \exp(-T_{ST} / \tau)$ Probability that leak is not repaired in interval T_{ST}

$$\pi_1 = \frac{1-\beta}{pD}\left[1-(1-q)\delta - \varepsilon q\right]$$

$$\pi_2 = 1/D$$

$$\pi_3 = \frac{1-\beta}{D}$$

$$\pi_4 = \frac{(1-\beta)q}{D}$$

$$D = \frac{1-\beta}{p}\left[1-(1-p)\delta - \varepsilon q\right] + 1 + (1-\beta) + (1-\beta)q$$

Steady-state solutions to the embedded Markov chain

$$\boxed{P_{234} = \frac{M_2 + (1-\beta)M_3 + (1-\beta)qM_4}{\frac{1-\beta}{p}\left[1-(1-p)\delta - \varepsilon q\right]M_1 + M_2 + (1-\beta)M_3 + (1-\beta)qM_4}}$$

Using Containment Pressure in Determining Available NPSH

Applications of Risk Insights

Marty Stutzke
Division of Risk Assessment
Office of Nuclear Regulatory Research

May 2010

Summary of Risk Insights

- There is only one minimal cut set where the loss of containment integrity leads directly to core damage (large LOCA).
- The increase in internal event CDF can be made very small (<10-6/y, as defined in RG 1.174) with adequate testing of containment integrity.
- The increase in seismic CDF, based on a simplified and conservative analysis, meets the numerical risk acceptance guidelines in RG 1.174 for all plants.
- Determanistic guidance is needed to address fire risk (no numerical risk results exist).

Regulatory Roadmap

SECY-99-246
(10/12/1999)

SRM on SECY-99-246
(1/5/2000)

RIS 00-07
(3/28/2000)

COMSECY-00-0038
(11/13/2000)

SRM on COMSECY-00-0038
(11/22/2000)

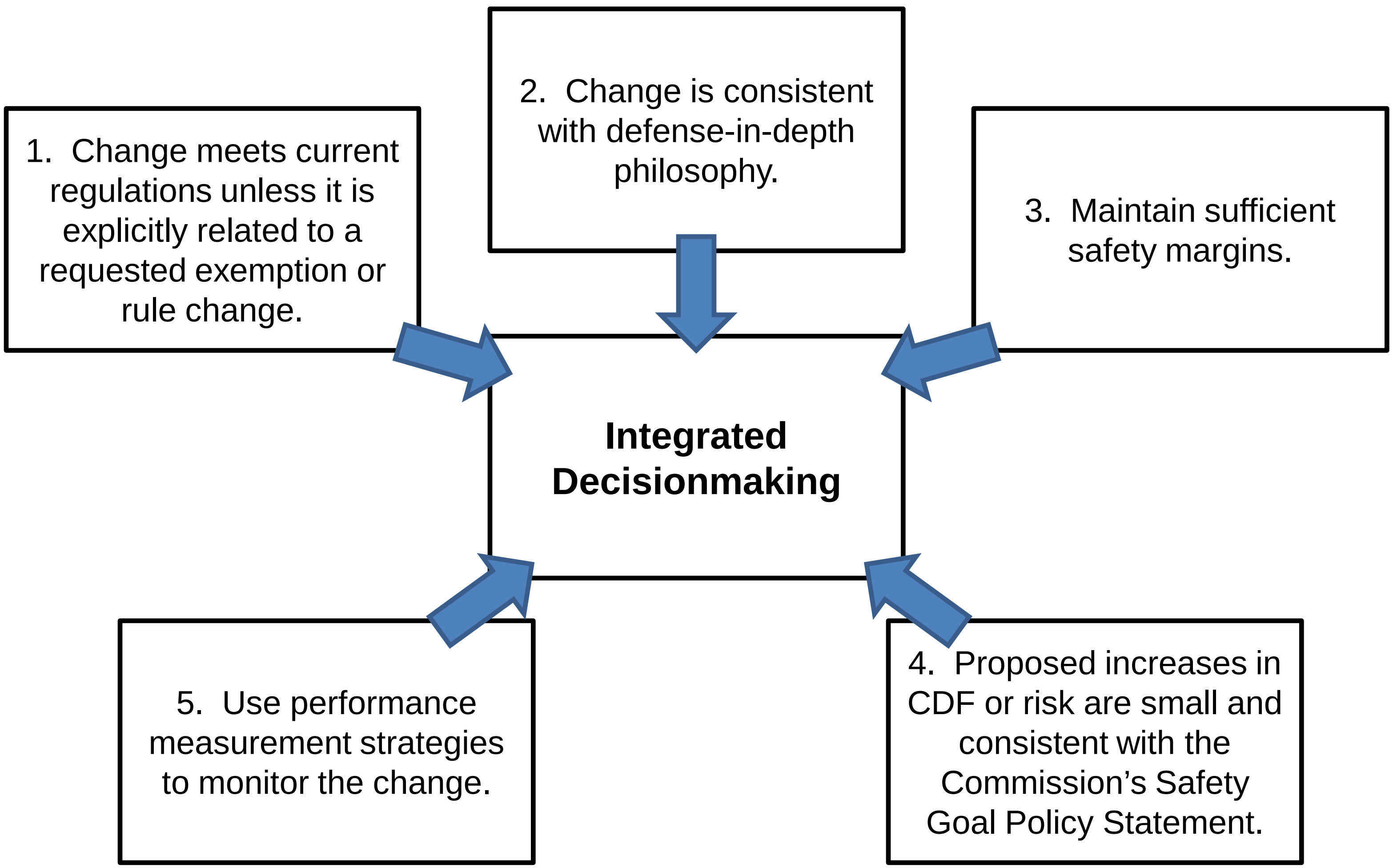
RIS 01-02
(1/18/2001)

RG 1.174

SRP Section 19.2, App. D
Use of Risk Information in Review of Non-Risk-Informed License Amendment Requests

The numerical guidance on CDF and LERF and the safety principles in RG 1.174 are intended to provide a basis for finding that there is reasonable assurance of adequate protection.

Five Key Principles of Risk-Informed Decisionmaking



Defense-in-Depth

- The Commission's White Paper on Risk-Informed and Performance-Based Regulation (SRM to SECY-98-144, March 1, 1999):
  - Defense-in-depth is an element of the NRC's Safety Philosophy that employs successive compensatory measures to prevent accidents or mitigate damage if a malfunction, accident, or naturally-caused event occurs at a nuclear facility.
  - The defense-in-depth philosophy ensures that safety will not be wholly dependent on any single element of the design, construction, maintenance, or operation of a nuclear facility.
  - Decisions on the adequacy of or the necessity for elements of defense should reflect risk insights gained through identification of the individual performance of each defense system in relation to overall performance.

Advisory Committee Views

- ACRS Letter, “The Role of Defense in Depth in and Risk-Informed Regulatory System,” May 19, 1999:
  - Our motivation for this report has arisen because of instances in which seemingly arbitrary appeals to defense in depth have been used to avoid making changes in regulations or regulatory practices that seemed appropriate in the light of results of quantitative risk analyses.
  - Unless defense-in-depth measures are justified in terms of necessity and sufficiency, the full benefits of risk-informed regulation cannot be realized.
- Joint ANCW and ACRS Letter, “Use of Defense in Depth in Risk-Informing NMSS Activities,” May 25, 2000:
  - Defense in depth is a strategy to ensure public safety given unquantified uncertainty in PRAs.
  - The nature and extent of compensatory measures should depend on:
    - The degree of uncertainty, and
    - The degree of risk posed by the activity.
  - How good each compensatory measure should be is a value judgment and, thus, a matter of policy.

RG 1.174, Section 2.2.1.1 Guidance

- Consistency with the defense-in-depth philosophy is maintained if:
  - A reasonable balance is preserved among prevention of core damage, prevention of containment failure, and consequence mitigation.
  - Over-reliance on programmatic activities to compensate for weaknesses in plant design is avoided.
  - System redundancy, independence, and diversity are preserved commensurate with the expected frequency, consequences of challenges to the system, and uncertainties (e.g., no risk outliers).
  - Defenses against potential common cause failures are preserved, and the potential for the introduction of new common cause failure mechanisms is assessed.
  - Independence of barriers is not degraded. CAP credit concern
  - Defenses against human errors are preserved.
  - The intent of the General Design Criteria in Appendix A to 10 CFR Part 50 is maintained.

SRP Section 19.2 Subsection III.2.1.1.1 Guidance

- The change does not result in a significant increase in the existing challenges to the integrity of barriers.
- The change does not significantly change the failure probability of any individual barrier.
- The proposal does not introduce new or additional failure dependencies among barriers that significantly increase the likelihood of failure compared to the existing conditions.
- The overall redundancy and diversity among the barriers is sufficient to ensure compatibility with the risk acceptance guidelines.

Defense in Depth and the Use of Containment Pressure in Determining Available NPSH

- No changes to any programmatic element (e.g., inspections) that provides defense-in-depth.
- Proposed staff guidance:
  - Considers T/H uncertainties in NPSHA and NPSHR.
  - Specifies adequate containment integrity monitoring.
- The size of a containment leak that causes loss of NPSH is smaller than the size associated with a large early release:
  - 20-40 La compared to > 100 La
  - Therefore: ΔCDF > ΔLERF

Risk Insights and “Practicably Altered”

- Staff guidelines state that licensees should justify that use of containment accident pressure is necessary because the design cannot be practicably altered.
- Numerical risk results may make this guideline moot for BWRs with Mark I containments:
  - The increase in internal event CDF can be made very small with adequate containment integrity surveillance.
  - Seismic risk may be a major contributor, depending on:
    - Site-specific seismic hazard curves
    - Containment seismic fragility
  - Based on the regulatory (value-impact) analysis guidelines provided in NUREG/BR-0184:
    - Assume $\Delta CDF = 10^{-6}$/y due to the CAP credit.
    - $74K justified to avoid using the CAP credit.

ACRS / BWROG - Containment Accident Pressure

Alan Wojchouski
Xcel Energy
BWROG CAP Committee Chair

May 6, 2010

Summary

I. Tech Specs and operator monitoring would detect a loss of containment integrity that affects NPSH margin. Tech Specs require prompt actions

II. Realistic analysis shows that for loss of containment integrity with a DBA LOCA, credit for containment accident pressure is not needed

III. For design basis and beyond design basis events, loss of primary containment defense barrier can be mitigated prior to loss of the fuel defense barrier

- Operator actions to mitigate loss of containment integrity can be taken to assure adequate NPSHa for ECCS pump operation and core cooling

I. Containment Integrity

Programs exist to assure containment leakage does not approach the level needed to lose NPSH margin

- Containment designed to maintain its integrity
- Operating license requirements assure containment integrity will be maintained:
  - Primary Containment Isolation System including valve alignment verification
  - Appendix J Test Program
  - Containment Boundary In-service Inspection Program
  - Operational containment leakage monitoring
  - Technical Specifications require prompt shutdown if containment integrity lost during operation

I. Appendix J and Technical Specifications

Appendix J Program requires testing of containment leakage paths at each refueling outage

•Tech Spec requirement: containment leakage is 1.0 La (leak acceptance criteria)

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Primary containment inoperable.	A.1 Restore primary containment to OPERABLE status.	1 hour
B. Required Action and associated Completion Time not met.	B.1 Be in MODE 3. AND B.2 Be in MODE 4.	12 hours 36 hours

I. Operational Containment Leakage Monitoring for Pre-Existing Leaks

Gross containment leakage of magnitude sufficient to affect NPSH margin would be monitored by:

- Drywell pressure
- Containment oxygen concentration
- Nitrogen consumption

I. Operational Containment Leakage Monitoring for Pre-Existing Leaks

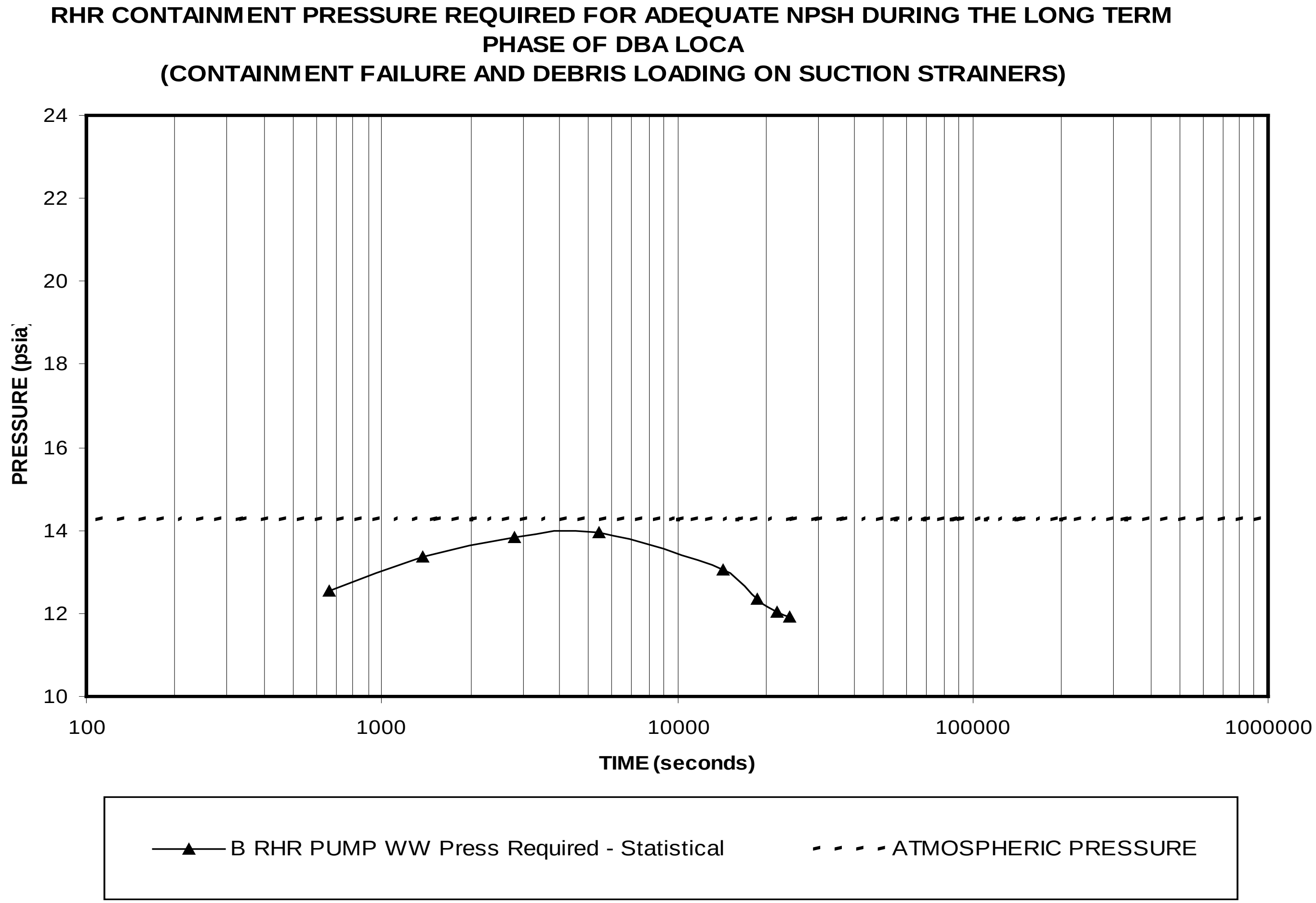
Drywell pressure and Excess Nitrogen Make-up

- Drywell pressure maintained between 0.1 psig and 1.5 psig
- Alarms for values outside the allowable range
- Excess use of nitrogen make-up indicates a possible containment leakage problem
- Operators would confirm and initiate an investigation per corrective action program

Containment oxygen concentration

- Technical Specifications requires that primary containment oxygen concentration shall be < 4.0 %
- Inability to maintain oxygen within limits indicates a possible containment leakage problem
- Operators would confirm and initiate an investigation per corrective action program

II. Realistic Analysis with Loss of Containment Integrity (NEDC-33347P)



III. Operator Actions Can Mitigate Loss of Containment Integrity During Events

Long-term NPSH can be maintained by operator actions by increasing suppression pool water level when there is no accident pressure available

Alternate injection systems can increase suppression pool water level and maintain reactor vessel water level

- Backup to ECCS following initial core flooding
- EOPs at example plant provide instructions to use alternate water sources such as RHRSW, Condensate Service Water, Fire Water, Service Water as available

Summary

I. Tech Specs and operator monitoring would detect a loss of containment integrity that affects NPSH margin. Tech Specs require prompt actions

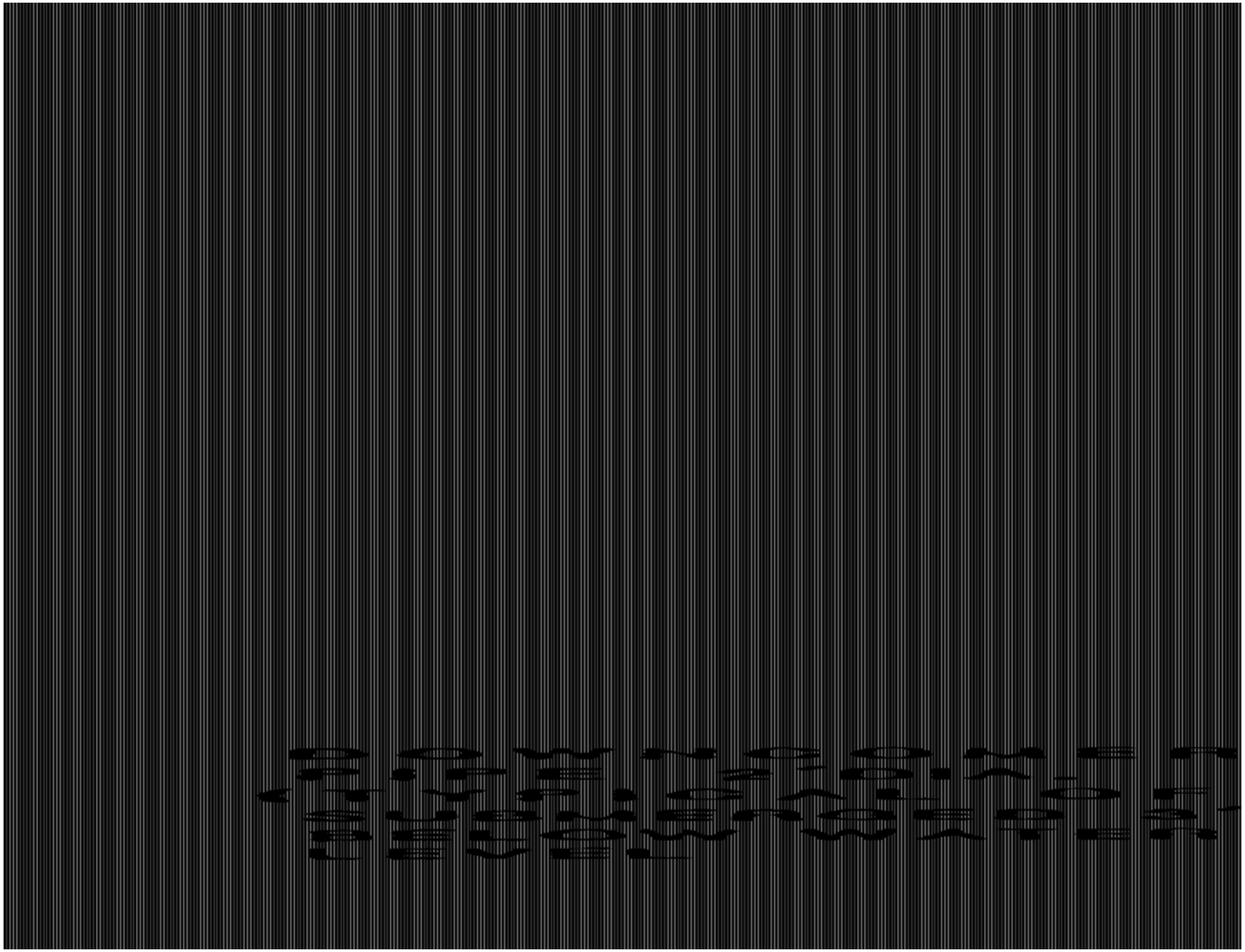
II. Realistic analysis shows that for loss of containment integrity with a DBA LOCA, credit for containment accident pressure is not needed

III. For design basis and beyond design basis events, loss of primary containment defense barrier can be mitigated prior to loss of the fuel defense barrier

- Operator actions to mitigate loss of containment integrity can be taken to assure adequate NPSHa for ECCS pump operation and core cooling

Backup slides to BWROG May 6 presentation to ACRS on Containment Accident Pressure

BWR Mark I Containment



Pre-Existing Leak in Containment

Typically, the nitrogen makeup system is not in service. When the nitrogen makeup system is in service the maximum nitrogen makeup flow rate is

2 SCFM

Gross containment leakage that would affect NPSH margin is ~40 La or 40 times 458 SCFH = 305 SCFM

Therefore, the low Drywell pressure alarm could not be cleared. Containment leakage would be determined to exceed 1.0 La and TS actions entered.

Pre-Existing Leak in Containment

Technical Specifications requires that primary containment oxygen concentration shall be < 4.0 volume percent during power operations.

Primary containment oxygen concentration is required to be verified within limits every 7 days.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Primary containment oxygen concentration not within limit.	A.1 Restore oxygen concentration to within limit.	24 hours
B. Required Action and associated Completion Time not met.	B.1 Reduce THERMAL POWER to ≤ 15% RTP.	8 hours

USE OF CONTAINMENT ACCIDENT PRESSURE IN DETERMINING THE AVAILABLE NET POSITIVE SUCTION HEAD (NPSH) OF EMERGENCY CORE COOLING SYSTEM AND CONTAINMENT HEAT REMOVAL PUMPS

May 6, 2010

ACRS

Richard Lobel

Ahsan Sallman

Containment Accident Pressure vs. Overpressure

- Staff uses the term *containment accident pressure.*
- No system, structure or component is being overpressurized.
- *Overpressure* has been used several different ways:
  - Pressure greater than atmospheric pressure
  - Pressure greater than saturation pressure
  - Pressure greater than containment pressure prior to postulated accident (containment accident pressure)
  - BWROG topical report uses the first definition
- Containment accident pressure is greater than the containment pressure prior to the postulated accident

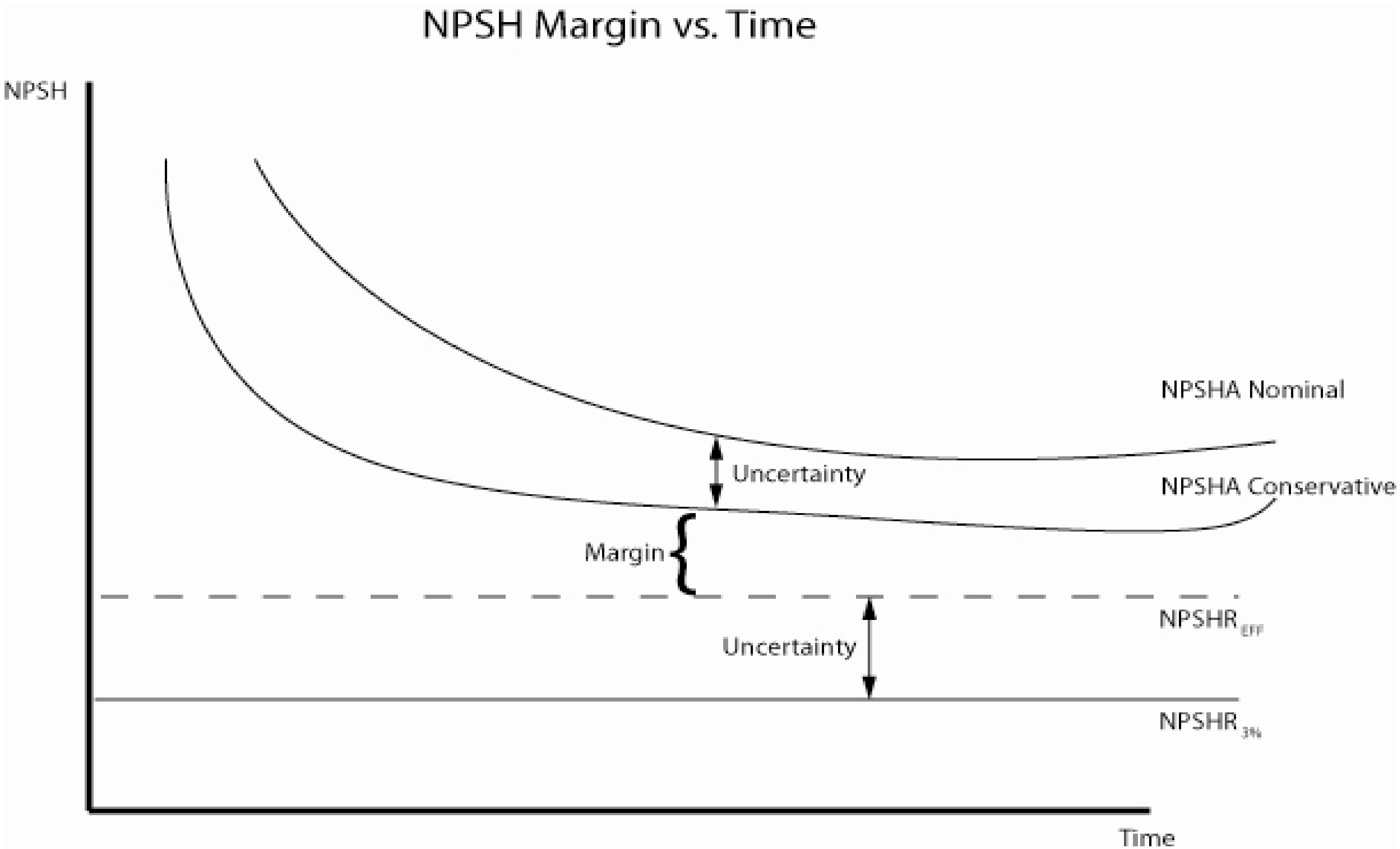
Status

- 27 operating reactors use containment accident pressure for determining available NPSH
  - 19 BWRs
  - 8 PWRs
- Extended power uprates:
  - Two EPU reviews on hold pending revised guidance on use of containment accident pressure for available NPSH

Proposed Guidance Key Ideas

- Design basis and “special events” are considered
- Containment integrity is assumed
  - New criterion proposed to ensure against pre-existing leak
  - Appendix R Fire associated circuits will not result in loss of containment integrity
  - Venting by procedure will not occur when containment accident pressure is needed
- Staff guidelines focus on pump performance (NPSH margin and adverse effects on pump)
- Quantitative guidelines are proposed

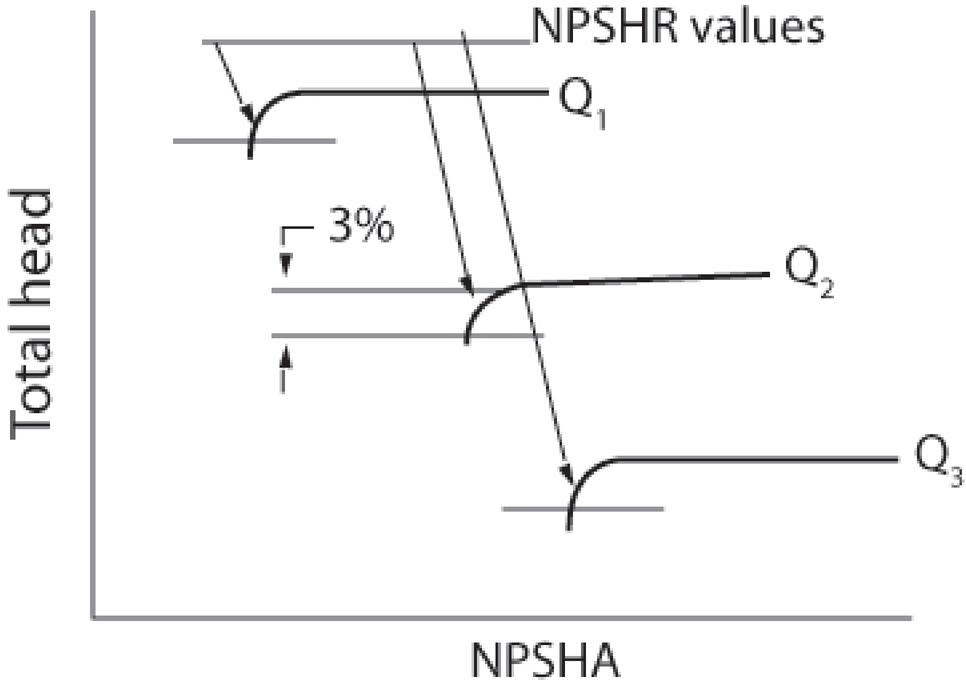
Margin and Uncertainty



Cavitation

- Cavitation is the formation of vapor in a liquid due to a decrease in the local static pressure followed by an increase in local static pressure which results in the sudden condensation of the vapor.
  - Occurs at constant liquid temperature.
- Excessive pump cavitation can result in:
  - Erosion of the pump impeller and other pump parts
  - Mechanical damage to seals, bearings, shaft, etc.
  - Decrease in pump flow rate
  - Decrease in pump discharge head
  - Vibration
- The degree to which any of these effects adversely affects pump performance depends on the amount of cavitation and its duration, the air/gas content of the liquid, the suction energy of the pump, the NPSH margin, and if the pump is operating in the low flow suction recirculation region.

Required NPSH



NPSHR DETERMINATION WITH SPEED AND FLOW RATE(Q) HELD CONSTANT

- Two natural NPSH values: incipient cavitation and break down.
- Others values of NPSH, such $NPSHR_{3\%}$, specify an arbitrary level of cavitation.

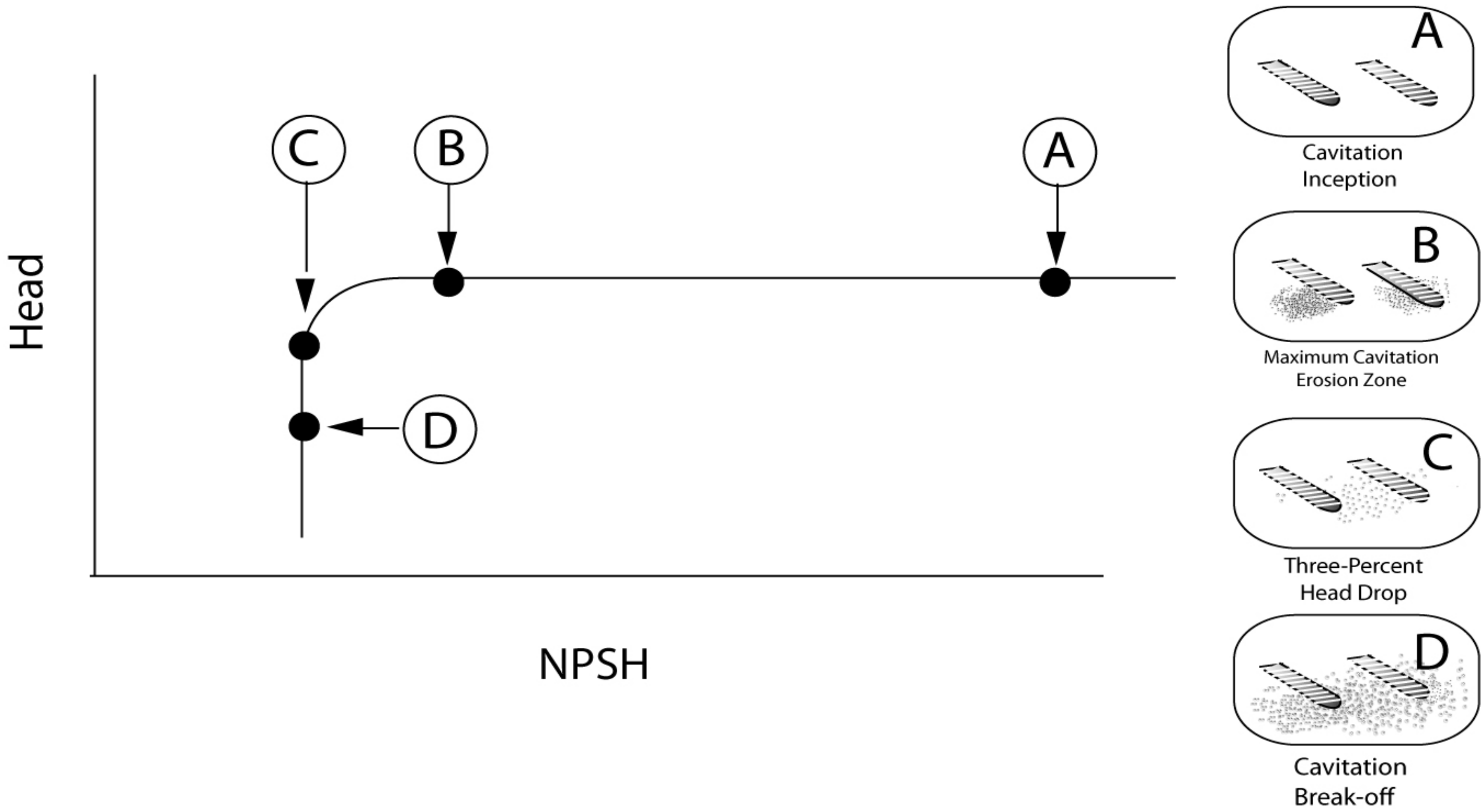
NPSHR Uncertainty

- Pump vendor test results for $NPSHR_{3\%}$ are most accurate. For best accuracy, test should be conducted at rated pump speed and impeller diameter with NPSHA controlled by vacuum pump.
- Additional uncertainty in $NPSHR_{3\%}$ due to field (installed) conditions.
- Installed uncertainty due to:
  - Pump speed
  - Water temperature
  - Suction piping layout
  - Air content of pumped water
  - Wear ring leakage
- Guidance defines a new parameter $NPSHR_{eff}$
  - $NPSHR_{eff} = (1.0 + \text{uncertainty})\ NPSHR_{3\%}$
  - $NPSHR_{eff}$ should be used in determining NPSHR margin
  - Value of NPSHR to be used in NPSH margin ratio not yet decided
  - For nondesign basis events, $NPSHR_{3\%}$ may be used for required NPSH

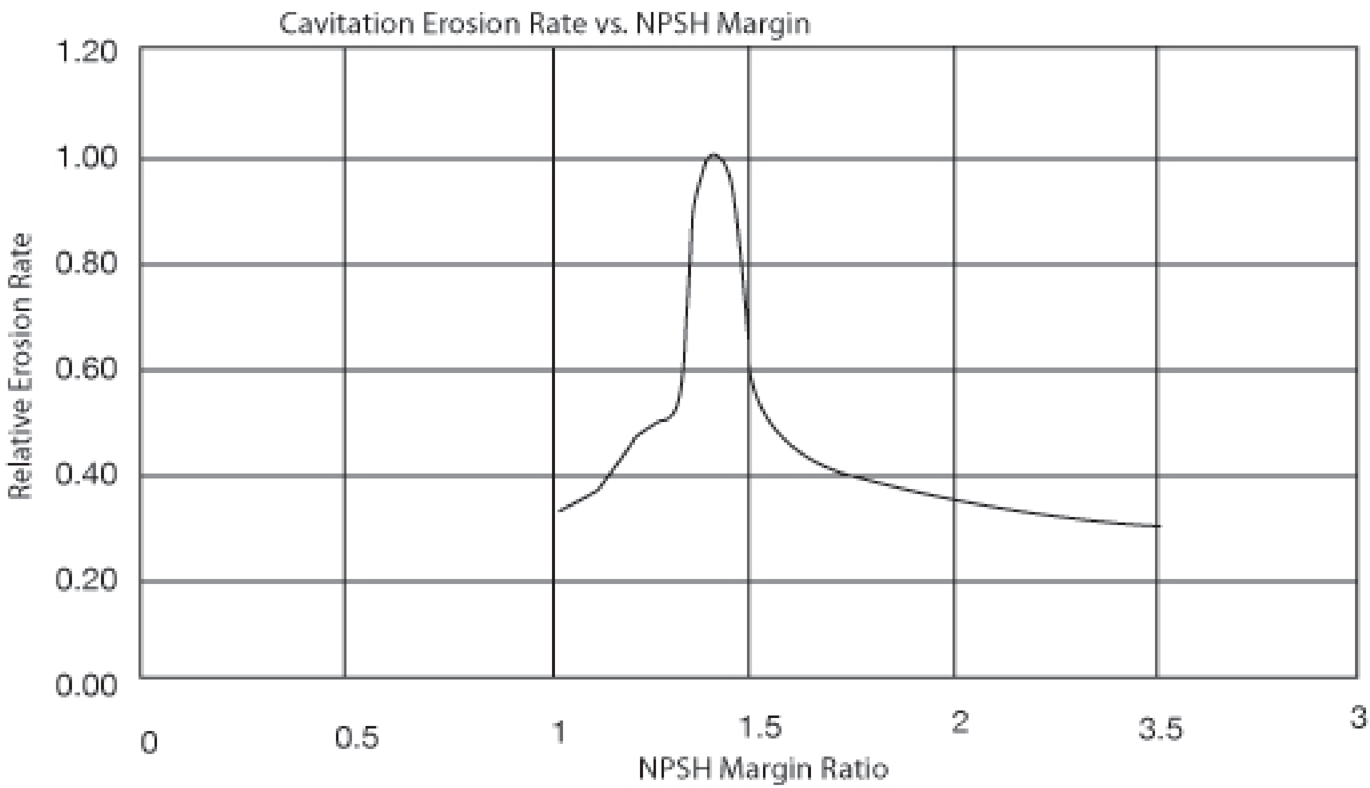
Cavitation Erosion

- Maximum cavitation erosion occurs between incipient cavitation and $NPSHR_{3\%}$.
- Only high and very high suction energy pumps will experience cavitation erosion damage in this zone.
- Using a typical curve of pressure transducer measurements of cavitation, the staff determined that the maximum erosion zone is between NPSH margin ratios of 1.2 and 1.6.
- The staff conservatively selected a limit of 100 hours for very high suction energy pumps as the maximum allowable time for operation in the maximum erosion zone.
  - Pump must continue to function for the remainder of its mission time (up to 30 days)
  - The pump would be at higher available NPSH values (out of maximum erosion zone) during post-accident operation

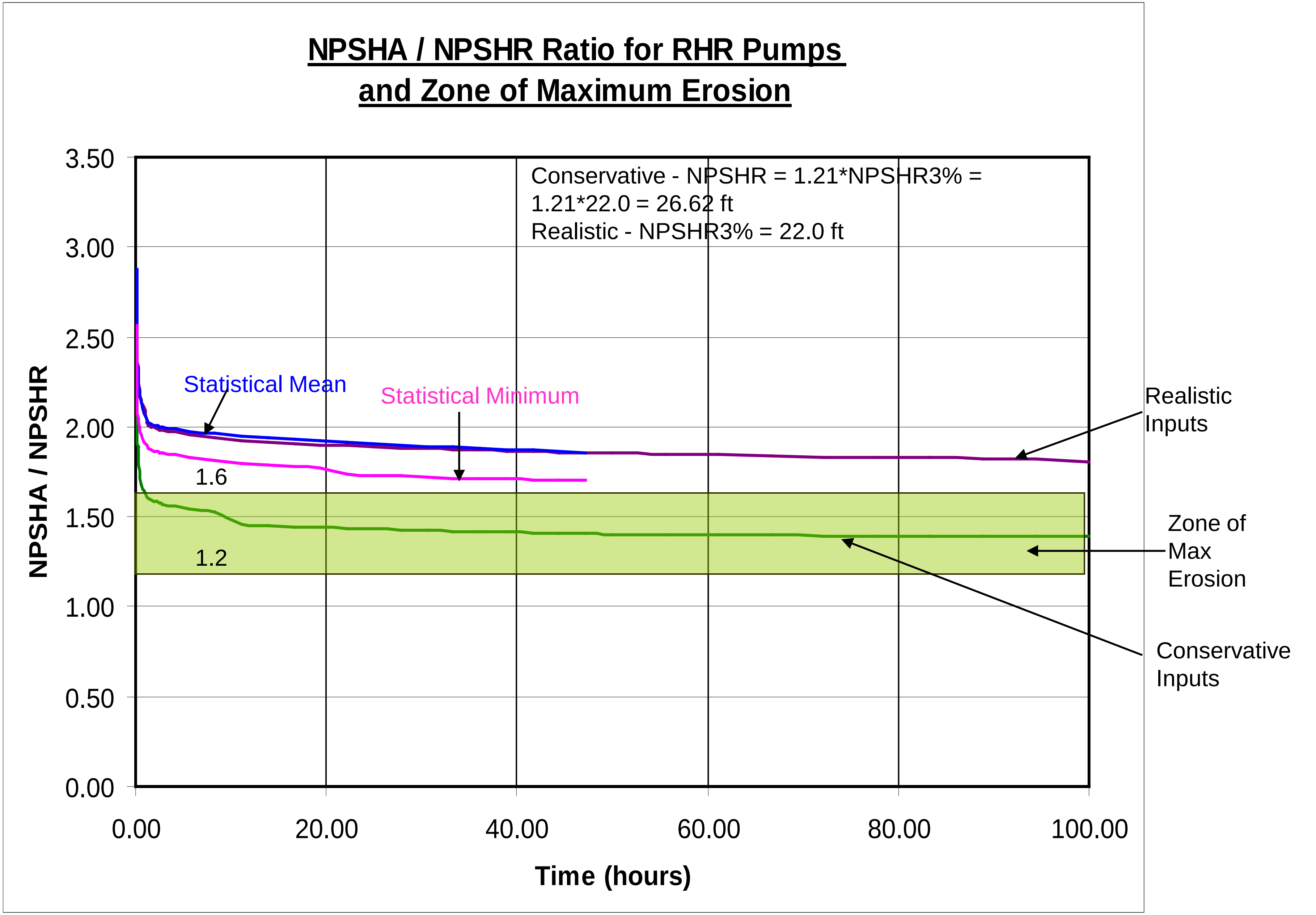
Cavitation Behavior Based on Impeller Voiding



Cavitation Acoustic Signal



Typical Relative Erosion Rate vs. NPSH Margin near BEP Flow Rate



NPSHA / NPSHR Ratio for RHR Pumps
and Zone of Maximum Erosion
Conservative - NPSHR = 1.21*NPSHR3% =
1.21*22.0 = 26.62 ft
Realistic - NPSHR3% = 22.0 ft
Statistical Mean
Statistical Minimum
1.6
1.2
Realistic
Inputs
Zone of
Max
Erosion
Conservative
Inputs
NPSHA / NPSHR
Time (hours)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
20.00
40.00
60.00
80.00
100.00

NPSHA < NPSHR

- It is possible that the predicted available NPSH for an event may be less than the required NPSH.
- RG 1.82 Revision 3 states that predicted operation with NPSHA < NPSHR is acceptable if testing shows that the pump will continue to perform its safety function.
- Staff has developed the following conditions which should apply to testing:
  - Time of predicted operation in cavitation less than 100 hours
  - Tests conducted on actual pump or important pump hydraulic properties the same
    - e.g., same model, size, impeller diameter
  - Tests conducted at same field speed
  - Test conducted with predicted NPSHA
  - Test should be for predicted time that NPSHA < NPSHR
  - Flow rate and discharge head remain above values assumed in core and containment cooling analyses
  - No damage or excessive wear to pump components

Protection of Mechanical Seals

- A concern with operating a pump at or below the 3% NPSHR condition is the damage that the water vapor and/or entrained air could do inside the pump to the mechanical shaft seal faces, which could fail in a very short time if the seal faces run dry.

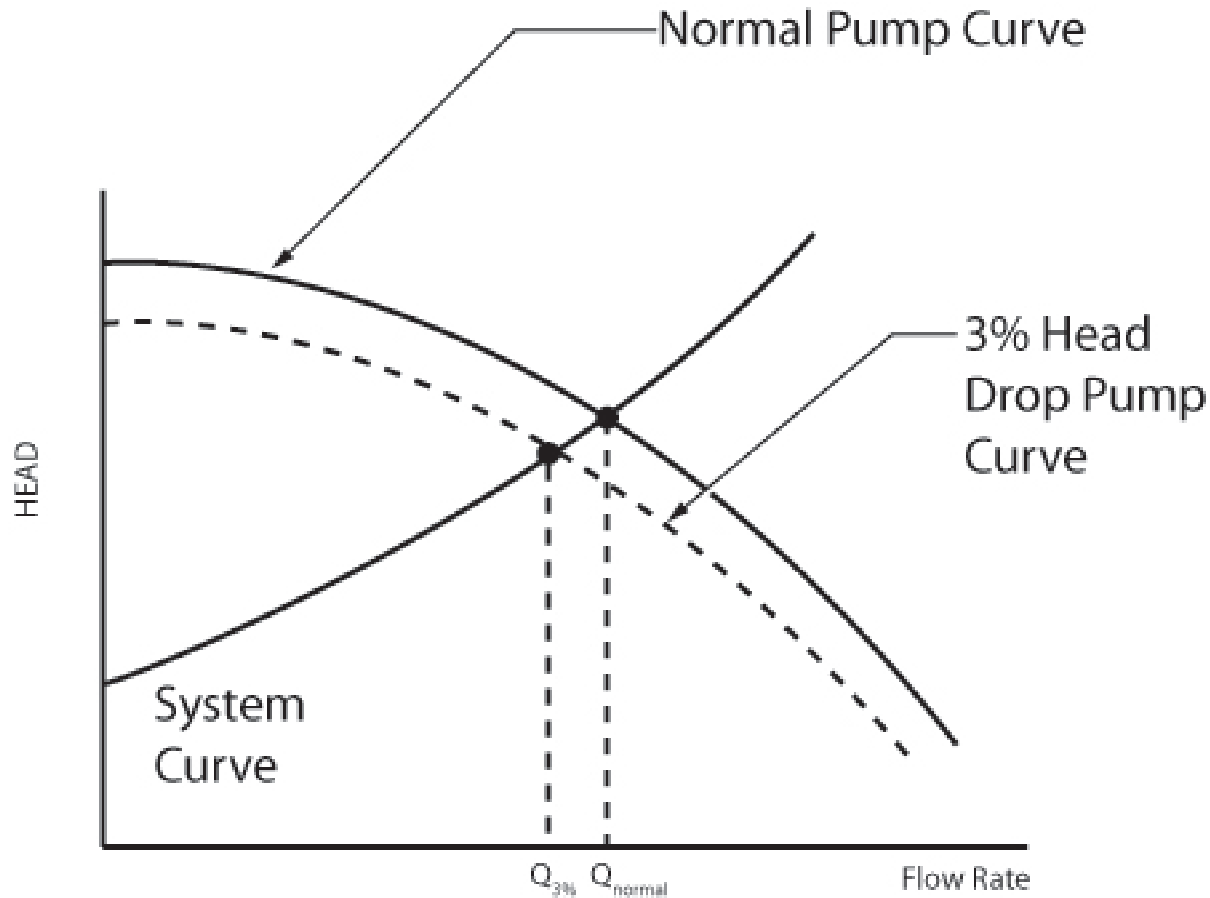
- Excessive entrained air may accumulate around the shaft, where the mechanical seal is housed.

- This additional entrained air comes from the dissolved air that comes out of solution as local static pressure drops to the vapor pressure and cavitation vapor bubbles are formed.

- To protect the mechanical seal faces from this excess entrained air (under operation at or below the 3% NPSHR condition), dual mechanical seals with an external cold water flush system (or equivalent) should be provided.
  - Necessity for this guideline may require individual pump evaluation

Pump Flow Rate

- The flow rate chosen for the NPSH analysis should be greater than or equal to the flow rate assumed in the safety analysis that demonstrates adequate core and containment cooling
- If the assumption that NPSHA = $NPSHR_{eff}$ or $NPSHR_{3\%}$ is used to determine the containment accident pressure used, then the pump flow rate used in the core and containment cooling analyses should be the flow rate resulting from a 3% decrease in pump total dynamic head



Normal Pump Curve
3% Head Drop Pump Curve
HEAD
System Curve
Q3% Qnormal
Flow Rate

Duration of Need for Containment Accident Pressure

- Staff concludes that a limit on the duration of use of containment accident pressure is not needed.
  - Not supported by risk analysis
  - Would be arbitrary (no technical basis)
- Staff has proposed a time limit in zone of maximum erosion rate of 100 hours

Reducing Containment Pressure by Cooling the Containment Atmosphere

- Licensee analysis should demonstrate that operation of sprays or fan coolers will not cause containment accident pressure to be less than that needed for adequate available NPSH.
  - BWR procedures contain a caution to this effect.
  - BWR calculations assume spray operation during time containment accident pressure is used.

- Restarting of spray pumps and fan coolers: plant specific

Proposed Containment Leakage Rate Surveillance

- To reduce the likelihood of a preexisting leak, licensees proposing to use containment accident pressure in determining NPSH margin should:
  - (i) Determine the minimum containment leakage rate sufficient to lose the containment accident pressure needed for adequate NPSH margin.
    - Staff and BWROG calculations predict this would be 40La.
  - (ii) Propose a method to determine if the actual containment leakage rate exceeds the leakage rate determined in (i) above.
    - For inerted containments, this method could consist of a periodic quantitative measurement of the nitrogen makeup performed at an appropriate frequency to ensure that no unusually large makeup of nitrogen occurs.
    - Monitoring oxygen content is another method.
    - For subatmospheric containments, a similar procedure might be used.
  - (iii) Propose a limit on the time interval that the plant operates when the actual containment leakage rate exceeds the leakage rate determined in (i) above.

Available NPSH (NPSHA) and Containment Analysis

- To determine available NPSH we must know:
  - containment pressures (drywell and wetwell)
  - containment temperatures (BWR drywell and wetwell atmospheres and suppression pool water)
  - water level above the pump suction
- Calculated with containment thermal hydraulic analysis code
- Staff guideline: Two calculations should be done to demonstrate margin in available NPSH:
  - Conservative
  - Realistic

NPSHA Staff Calculations

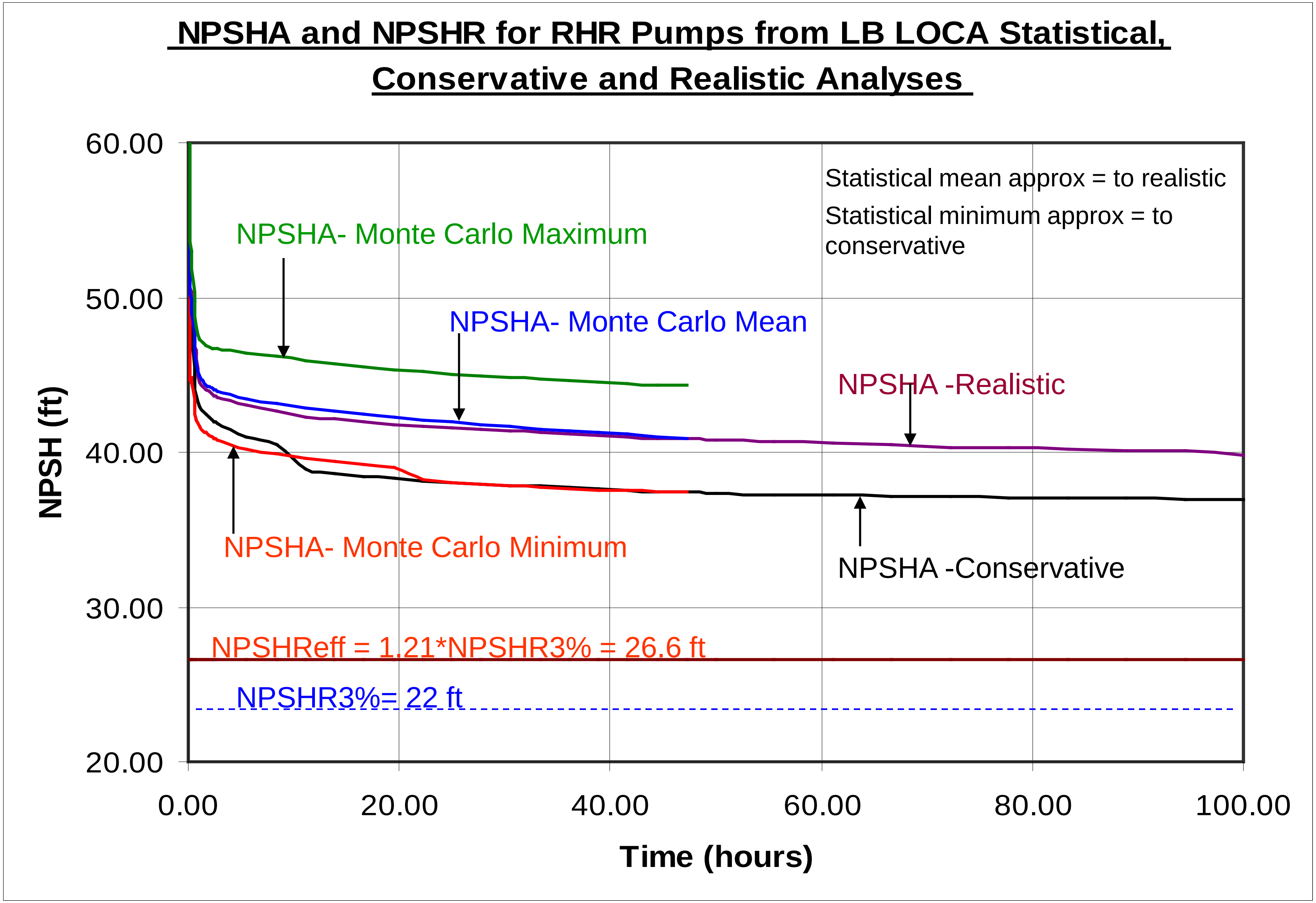
- Purpose of staff calculations
  - Prepare calculation models for future reviews
  - Study sensitivity of available NPSH and NPSH margin to input parameters, assumptions and calculation models
- Staff performed realistic, conservative and Monte Carlo calculations
- Realistic, conservative and Monte Carlo calculations assumed worst single failure
- Staff calculations use GOTHIC
- Staff calculations are not meant to reflect expected licensing calculation results
  - Staff does not have complete plant data, especially for more realistic input parameters
    - BWROG and licensees have provided the information the staff requested
  - Some staff calculations performed in a different way than BWROG: methods (computer codes) and models (e.g., modeling of decay heat for statistical models, heat transfer coefficients)
  - However, conclusions are considered generally applicable to BWRs with Mark I containments so that guidance can be formulated

NPSHA Sensitivity Studies

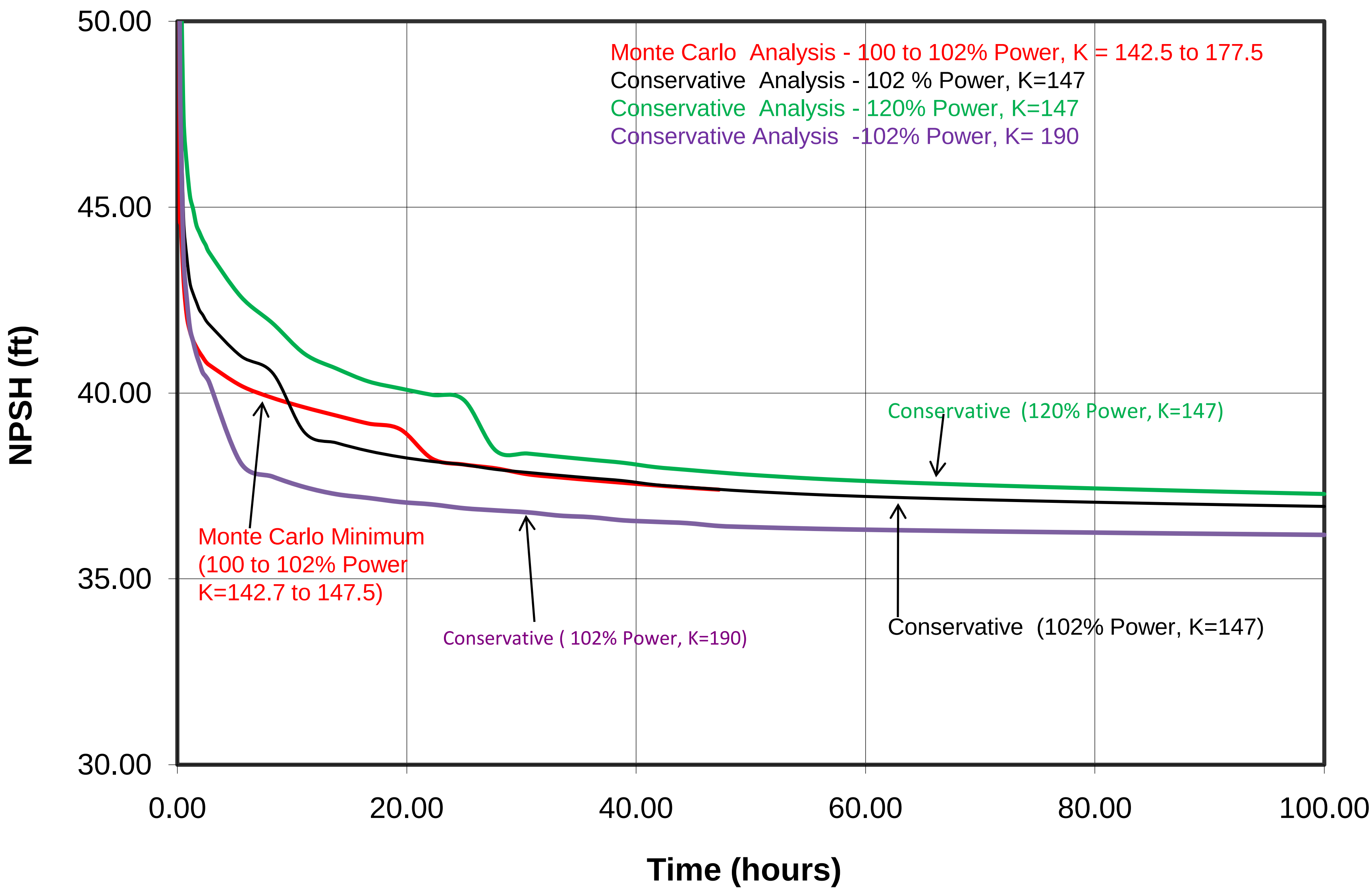
- Staff performed sensitivity studies of input variables to NPSH calculation for a LOCA in a BWR/4 with a Mark I containment
- Most variables varied by 5%.
- Conservative inputs used for base case (except 100% power instead of 102%)

BWR-4 MARK I CONTAINMENT LONG TERM LOCA NPSH ANALYSIS SENSITIVITY STUDY RESULTS SUMMARY

No	Parameter	Base Value	Compared Value	Change in Parameter Value (%) (Note 1)	Maximum Change in Supp Pool Temp (%)	Maximum Change in Wetwell Pressure (%)	Maximum Change in Available NPSH (%)
1	Power (percent)	100	95	-5	-2.34	-5.47	-4.24
2	Core Spray Flow (gpm)	3027	2876	-5	-0.17	1.12	2.67
3	Initial Drywell Pressure (psia)	14.26	14.97	5	-0.1	2.02	2.53
4	Initial Wetwell Pressure (psia)	14.26	14.97	5	-0.2	2.16	2.32
5	Initial Supp Pool Temp (deg F)	90	85.5	-5	-2.93	-3.89	-2.27
6	Service Water Temperature (deg F)	90	85.5	-5	-2.63	-3.83	-2.26
7	RHR HX K-Value (Btu/sec deg F)	147	139.65	-5	2.76	4.89	2.14
8	Initial Drywell Temperature (deg F)	135	128.25	-5	-0.12	1.58	2.02
9	Initial Torus Liquid/Volume Ratio	0.3858	0.4051	5	-1.82	-3.67	1.29, -0.96
10	Reactor thermal conductors area reduced by 5%	100%	95%	-5	-0.38	-1.11	-0.98
11	Drywell Spray Flow	3800	3610	-5	-0.08	0.77	0.88, -0.22
12	Strainer & Piping Loss (ft)	5.79	5.5	-5	0	0	0.78
13	Initial Drywell Relative Humidity (%)	100	95	-5	-0.09	0.44, -0.72	0.67, -0.76
14	Wetwell Spray Flow	200	190	-5	-0.01	0.34, -0.08	0.54, -0.09
15	Decay Heat (sigma)	2	1.9	-5	-0.12	-0.22	0.21, -0.45
16	Containment Leakage (Weight%/day)	1.2	1.26	5	0.01, -0.03	0.12, -0.14	0.16, -0.17
17	Decay Heat (sigma)	2	0		-4.36	-8.14	-5.04
18	Containment Leakage (Weight%/day)	1.2	6.0	500	-0.02	-2.31	-2.86
19	Passive Heat Sinks	Present	Absent	-	1.31	2.12, -0.15	1.52, -0.03
20	Heat Transfer Coefficient for Containment Heat Sinks	Empirical	Heat & Mass Transfer Analogy	-	0.31, -0.01	0.08, -3.34	0.13, -3.65


NPSHA and NPSHR for RHR Pumps from LB LOCA Statistical, Conservative and Realistic Analyses
Statistical mean approx = to realistic
Statistical minimum approx = to conservative
NPSHA- Monte Carlo Maximum
NPSHA- Monte Carlo Mean
NPSHA -Realistic
NPSHA- Monte Carlo Minimum
NPSHA -Conservative
NPSHReff = 1.21*NPSHR3% = 26.6 ft
NPSHR3%= 22 ft
NPSH (ft)
60.00
50.00
40.00
30.00
20.00
0.00
20.00
40.00
60.00
80.00
100.00
Time (hours)

NPSHA for RHR Pumps from LB LOCA Conservative and Monte Carlo Analysis



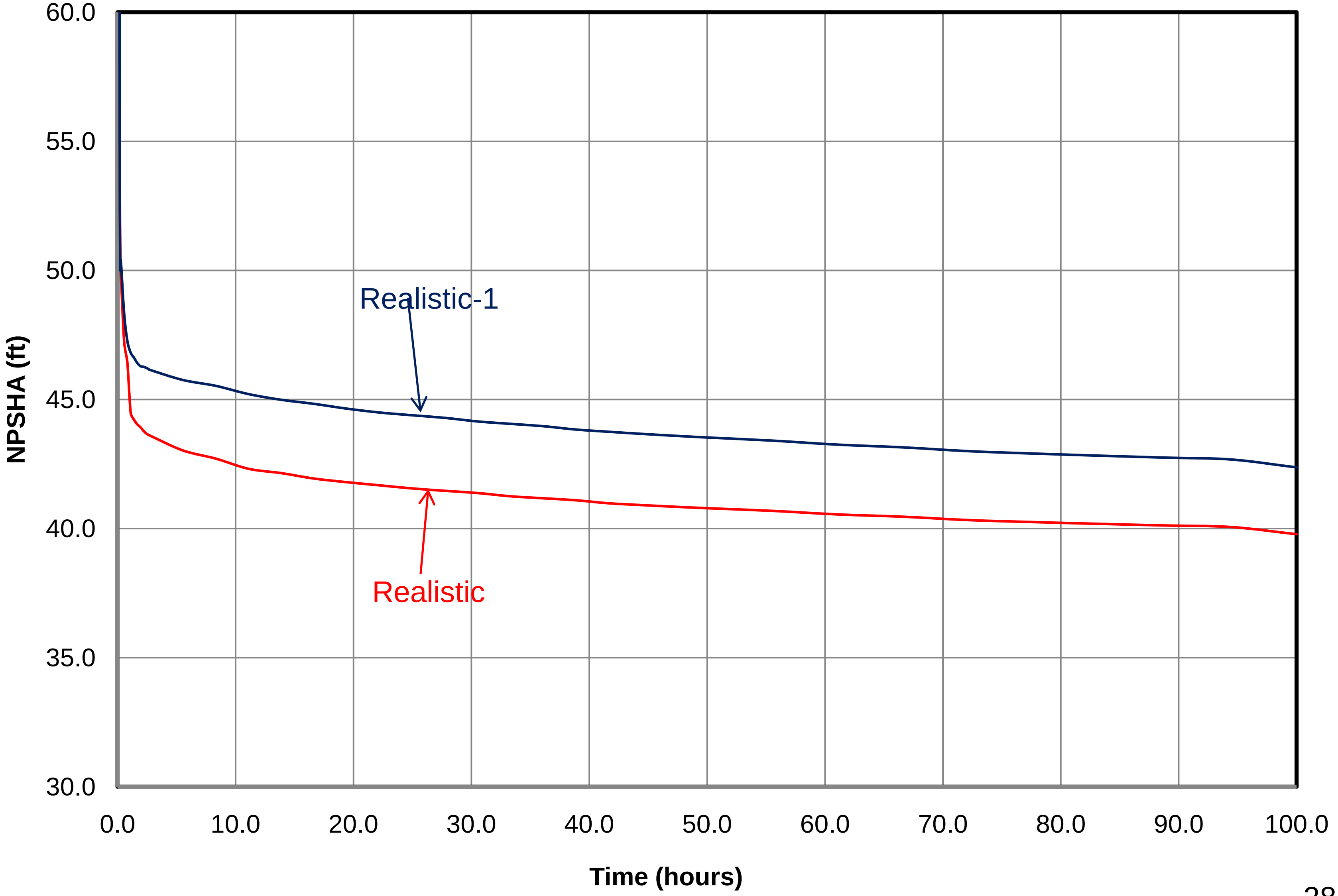
Comparison of Conservative, Realistic, and Statistical Inputs

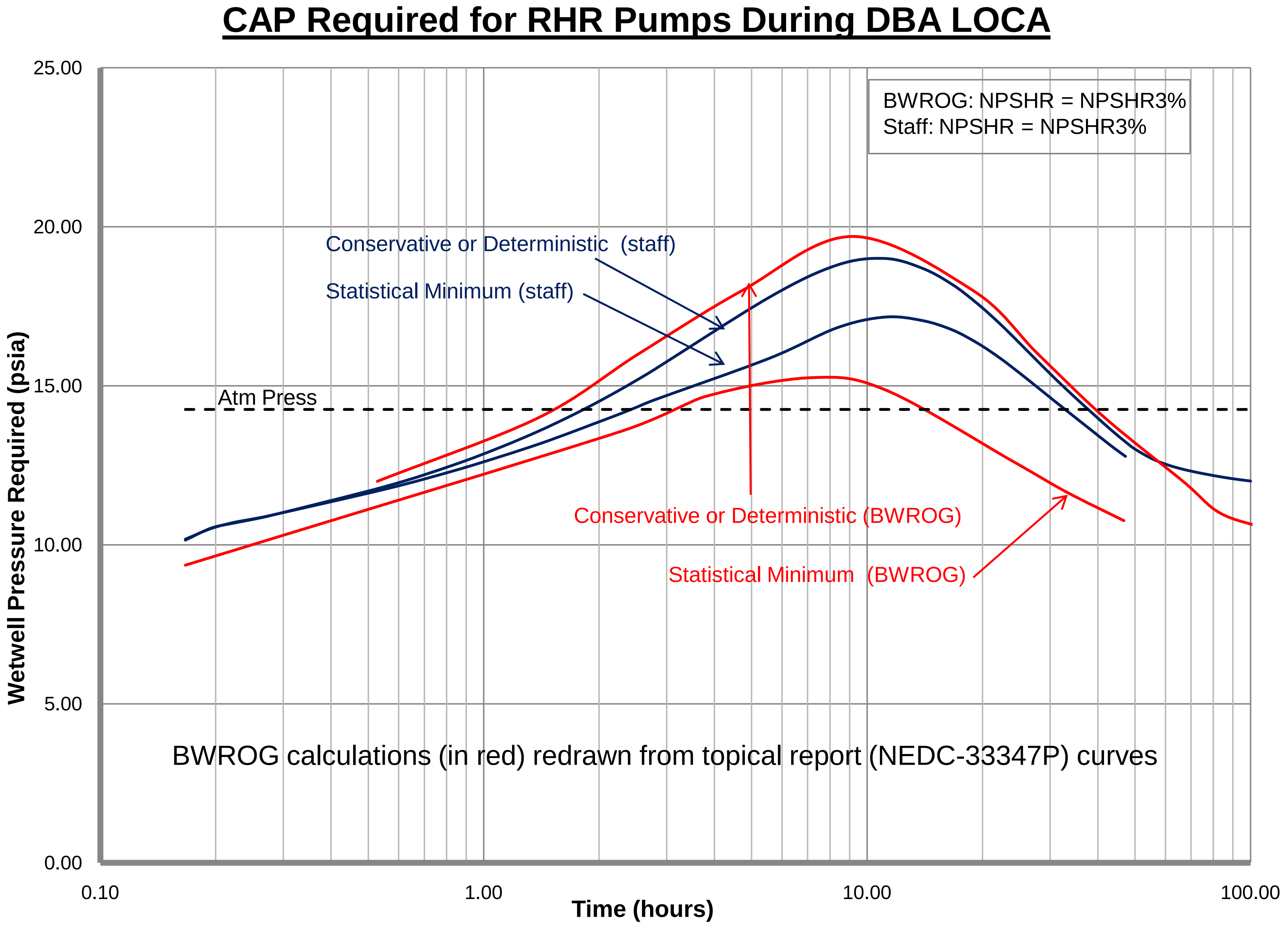
Parameter	Conservative	Realistic	Statistical	Comment
Power (%)	102	100	100 to 102	
Decay heat	ANS 5.1-1979 +2σ	ANS 5.1-1979 +0σ	ANS 5.1-1979 +0σ to +2σ	Linear interpolation between 0 & 2σ for a randomly selected σ
DW Pressure (psia)	14.26 (atm press)	15.76	14.26 to 15.51	15.51 is based on plant data, 15.76 is based on ΔP DW to WW = 1.5 psi
WW Pressure (psia)	14.26 (atm press)	14.26 (atm press)	14.26 to 15.51	15.51 is based on plant data
DW Temp (deg F)	135 (max DW Temp)	135 (max DW Temp)	72.5 to 122.5	
WW Temp (deg F)	90	90	65 to 95	
Supp Pool Level	Minimum TS Limit	Minimum TS Limit	Minimum TS to Maximum TS Limit	
Service Water Temp (deg F)	90	90	32 to 90	
RHR Hx K-Value (Btu/s ^{o}F)	147	158	142.5 to 177.5	
DW Relative Humidity (%)	100	40	100	> 40 for may increase unidentified leakage
WW Relative Humidity (%)	100	100	100	
Mass & Energy	Based on reactor at 1040 psia and 549.5 ^{o}F	Based on reactor at 1040 psia and 549.5 ^{o}F	Based on reactor at 1040 psia and 549.5 ^{o}F	LB LOCA during reactor normal operation
Containment leakage	1.2 Weight% /day (La)	1.2 Weight% /day (La)	1.2 Weight% /day (La)	Tech Spec limit
Strainer and piping head loss	Based on maximum flow and pipe routing with maximum head loss	Based on maximum flow and pipe routing with maximum head loss	Based on maximum flow and pipe routing with maximum head loss	

Comparison of Realistic and Realistic-1

Parameter	Realistic	Realistic-1	Comment
Power (%)	100	100	
Decay heat	ANS 5.1-1979 +0σ	ANS 5.1-1979 +0σ	
DW Pressure (psia)	15.76	15.76	15.76 is based on ΔP DW to WW = 1.5 psi
WW Pressure (psia)	14.26 (atm press)	14.26 (atm press)	
DW Temp (^oF)	135 (max DW Temp)	97.5	97.5 is the average of the range in statistical analysis
WW Temp (^oF)	90	80	80 is the average of the range in statistical analysis
Supp Pool Level	Minimum TS Limit	Average of Minimum and Maximum level	
Service Water Temperature (^oF)	90	90	
RHR Hx K-Value (Btu/s ^{o} F)	158	160	
DW Relative Humidity (%)	40	40	> 40 for may increase unidentified leakage
WW Relative Humidity (%)	100	100	
Mass & Energy	Based on reactor at 1040 psia and 549.5 ^oF	Based on reactor at 1040 psia and 549.5 ^oF	LB LOCA during reactor normal operation
Containment leakage	1.2 Weight% /day (La)	1.2 Weight% /day (La)	Tech spec limit
Strainer and piping head loss	Based on maximum flow and pipe routing with maximum head loss	Based on maximum flow and pipe routing with maximum head loss	

NPSHA for RHR Pumps from LB LOCA Realistic and Realistic-1 Analyses




CAP Required for RHR Pumps During DBA LOCA
BWROG: NPSHR = NPSHR3%
Staff: NPSHR = NPSHR3%
Conservative or Deterministic (staff)
Statistical Minimum (staff)
Atm Press
Conservative or Deterministic (BWROG)
Statistical Minimum (BWROG)
BWROG calculations (in red) redrawn from topical report (NEDC-33347P) curves
Wetwell Pressure Required (psia)
Time (hours)
25.00
20.00
15.00
10.00
5.00
0.00
0.10
1.00
10.00
100.00

Guidelines-1

- 1. Propose use of $NPSHR_{eff}$ defined as
  - $NPSHR_{eff} = (1.0 + \text{uncertainty})\ NPSHR_{3\%}$
- 2. ~~Either a conservative or 95/95 lower tolerance limit~~ A conservative analysis should be used in determining the available NPSH
- 3. A realistic calculation of available NPSH should be performed to compare with available NPSH determined from a conservative ~~or Monte Carlo 95/95~~ calculation
- 4. Pump operation in the maximum erosion zone should be limited to less than 100 hours.

Guidelines-2

- 5. Maximum flow rate chosen for NPSH analyses should be greater than flow rate used for core and containment cooling analyses
- 6. The mission time of the pump must consider any operation necessary to maintain stable core and containment cooling post-accident.
- 7. Containment isolation should not be lost due to an Appendix R Fire (associated circuit) or containment venting (required by procedures)
- 8. ~~Operator action to control containment pressure is acceptable if justified by human factors considerations and included in appropriate procedures~~
- 9. Operation for a limited time with NPSHA<NPSHR is acceptable, if justified by testing

Guidelines-3

- 10. To protect the mechanical seal faces from excess entrained air (released during operation at the 3% NPSHR condition), dual mechanical seals with an external cold water flush system (or equivalent) should be provided
- 11. Licensees should justify that use of containment accident pressure is necessary because the design cannot be practicably altered. (Not necessary for BWRs with Mark I containments.)

Summary

- Containment integrity is assumed.
  - based on the rigorous requirements for containment integrity (regulations, technical specifications, procedures) and based on risk insights
- Staff guidelines focus on pump performance to ensure that ECCS and containment heat removal pumps are capable of performing their safety function(s)
  - NPSHR uncertainty quantified
  - Staff guidelines used to indicate margin
    - Between realistic and conservative NPSHA
    - Between NPSHA and NPSHR or $NPSHR_{3\%}$
- Other effects (e.g., maximum cavitation erosion and air) included in guidance
- Some guidance details have not been finalized. Staff expects more discussion with owners' groups
  - 100 hour limit on time in maximum erosion zone
  - Values of uncertainty in required NPSH
  - Value of NPSHR for use in NPSH margin ratio for maximum, erosion zone calculations