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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

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SUBCOMMITTEE ON EXTENDED POWER UPRATES

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FRIDAY,

APRIL 23, 2008

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ROCKVILLE, MARYLAND

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

MEMBERS PRESENT:

WILLIAM J. SHACK, Chairman

SAID ABDEL-KHALIK

J. SAM ARMIJO

SANJOY BANERJEE

DENNIS C. BLEY

MARIO V. BONACA

CHARLES H. BROWN, JR.

HAROLD B. RAY

MEMBERS PRESENT (Continued):

MICHAEL T. RYAN

JOHN D. SIEBER

JOHN W. STETKAR

NRC STAFF PRESENT:

ZENA ABDULLAHI, Cognizant Staff Engineer and Designated Federal Official

BOB DENNIG

RICHARD LOBEL

AHSAN SALLMAN

WILLIAM RULAND

MARTY STUTZKE

EDWIN HACKETT

ALSO PRESENT:

MIKE CROWTHERS

ALAN WOJCHOUSKI

GUANGJAN LI

ALLEN BUDRIS

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

(8:28 a.m.)

1. OPENING REMARKS

CHAIR SHACK: The meeting will now come to order. This is a meeting of the Power Uprate Subcommittee. I am William Shack, the Chairman of this Subcommittee meeting.

ACRS members in attendance are Said Abdel-Khalik, Sam Armijo, Sanjoy Banerjee, Mario Bonaca, Charlie Brown, Jack Sieber, Dennis Bley, Mike Ryan, and Harold Ray.

We have a consultant to help us today with this review: Dr. Graham Wallis. Zena Abdullahi is the ACRS staff, designated federal official for this meeting.

In this meeting, we will cover two related topics. The first topic is the proposed BWR licensing methodology and calculation technique for addressing the containment overpressure credit. The second topic is the NRC draft guidance to the industry for the use of containment accident pressure.

ACRS has expressed its views in crediting containment accident pressure in a series of letters dating back to a development of RG 1.1. Recently ACRs has issued a March 18th, 2009 letter which delineated the Committee's concerns and proposed some approaches.

We look forward to hearing about the BWR Owners' Group technique for quantifying the conservatisms and the containment analysis that factor into the available net-positive suction calculations.

We're also very interested in the staff's guidelines for crediting containment accident pressure needed for operation of the emergency core cooling system and heat removal system.

We have received no requests from the public to make a statement at today's meeting.

Portions of the meeting will be closed because details of GEH's proprietary information may be discussed. The Subcommittee agenda that is available in this meeting room delineates which segments of the meeting will be closed.

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

Therefore, we request that participants in this meeting use microphones located throughout the meeting room in addressing the Subcommittee. The participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard.

We did receive a request for telephone participation. We ask that the telephone participants identify themselves before the start of the meeting. Is anybody on the line?

(No response.)

CHAIR SHACK: Okay. I just wanted to make sure that when they come on, they come listen-in only mode.

MS. ABDULLAHI: This is Zena Abdullahi. I think they are all on. Can you please all identify yourselves? Hello?

(No response.)

MS. ABDULLAHI: The light is open.

CHAIR SHACK: We will now proceed with the meeting. I will call upon Alan Wojchouski of Xcel Energy, which is also representing the BWR Owners' Group, to begin.

2. BWROG - NEDC-33347P

MR. CROWTHERS: Before Alan gets started, my name is Mike Crowthers. I am with PPL Susquehanna. I am the Owners' Group Vice Chairman. I appreciate the opportunity to come and talk to ACRS today. As you recall, we were here back in 2008, when we provided presentation prior to submittal of the Topical to the staff.

We over the last couple of years have been addressing RAIs and working with the staff to resolve questions and concerns. We think we are at the point where the Topical is pretty much ready to be approved. And so we are here again to make that presentation.

We will be revising the Topical once the staff has finalized their review to incorporate the staff's feedback that we have received through the RAI process.

There is no proprietary information in our prepared slide. So unless we have to go there, we shouldn't have to use that. But if we do have to go to proprietary information, we'll let you know. And then we'll just have to hold those questions and comments to that point in the agenda where we have the time slotted.

I am going to turn it over to Alan. Alan is going to lead us through the presentation here. Alan has been the lead for the Owners' Group since the inception of this effort. Again, Alan is from Montecello.

Alan, all yours.

MR. WOJCHOUSKI: Take it off from there. Alan Wojchouski from Xcel Energy. I work at Montecello Nuclear Generating Plant. I have degrees in mathematics, physics, and computer science minor. I went on to Virginia Tech and got a Master's degree in nuclear engineering.

My career started off with Exxon Nuclear doing redesigns for Prairie Island's unit I and II and then went off to Montecello for the last 30 years. So at Montecello, I have been system engineer and in management chain, supervisor over those years and have also previously held a senior reactor operator's license.

With that, we'll start off with the presentation. The purpose of the presentation is to provide an overview of the Topical report. The Topical report was basically put together to provide a standardized predictable approach for the utilities to request containment accident pressure.

It goes ahead and outlines a deterministic method to calculate NPSHa and statistical method to demonstrate the margin inherent in the deterministic methodology. As I go through the presentation, each one of these different terms will be defined for you a little bit better.

Brief history of the Topical report. Late in 2005, the NRC requested the BWR Owners' Group to participate in trying to address several concerns that were raised by the ACRS.

So we sat down, formed a Committee, the Containment Accident Pressure Committee, and started work on putting together the licensing Topical report to address certain of those issues.

In February, we were here in front of the ACRS to go ahead and present the draft licensing Topical report. I gave a very similar presentation at that time. That was one week before we actually submitted the Topical report to the NRC staff for their review.

Since that time, we received numerous requests for additional information and provided the responses. The staff went ahead and provided a draft SE. We went ahead and commented on it. And right now they have a revised draft SE. And we'll hopefully shortly release that. That is where the current status is of the Topical report.

Basically the high-level overview of the Topical report has different sections. Each one of the different sections is listed in front of you. Basically the overview of the NPSH evaluation, how available NPSH evaluation is done for the BWR or for design basis LOCA, also NPSH considerations for special events, ATWS, station blackouts, appendix R type of events.

The safety basis for requesting containment accident pressure is also included in section number 5. We also on the technical type of a basis went ahead and proposed what from the technical input should be included in the licensing basis methodology. So also the elements of the license amendment request were discussed within the Topical report.

I am showing a slide of a BWR Mark I containment. The reason why I chose this is for BWRs, the Mark I containments are the ones that have been asking for containment accident pressure and have received them in the past.

To kind of go ahead and give you the main elements of it, I'll use my pointer. A large portion of it is the drywell, which poses -- houses, actually, the reactor vessel and the core and its auxiliary equipment, but you also notice coming off from the sides there are eight bent lines, which connect the drywell to the suppression chamber. The suppression chamber is in the lower part of the screen, which happens to be in the shape of a torus.

I will probably call the suppression chamber suppression chamber torus. Also, I will be calling the airspace above it the wetwell airspace. And also the water underneath it contains many thousands of gallons of water. That will be the torus temperature of the water into that that we'll be discussing.

The main purpose --

DR. WALLIS: What you don't show here is where the pumps are for the NPSH.

MR. WOJCHOUSKI: I don't.

DR. WALLIS: In some plants, they are very conveniently put down in holes so that they have a lot of head on them.

MR. WOJCHOUSKI: At Montecello, a lot of the Mark 1's, what we have is off of the torus is where we actually pull the section for the ECCS pumps. The ECCS pumps are generally in the corner of the rooms, this nice square building, right adjacent to the level of the torus. So you --

DR. WALLIS: Those are the ones that need more help.

MR. WOJCHOUSKI: That's correct.

DR. WALLIS: There is some literature in

holes, which --

MR. WOJCHOUSKI: If you have a deep --

DR. WALLIS: Right.

MR. WOJCHOUSKI: -- well pump, those are the ones that typically do not ask for containment accident pressure.

DR. WALLIS: So whether or nor you will need this overpressure depends a lot on where the pumps are and what kind of pumps they are.

MR. WOJCHOUSKI: That's correct. That's correct.

MEMBER BANERJEE: Are there any plants that need this without the uprates, the overpressure credit?

MR. WOJCHOUSKI: Yes. Montecello was one of those, even before we did a first uprate. We had within our tech spec basis that we needed containment accident pressure for certain periods of that.

MEMBER BANERJEE: How long was that?

MR. WOJCHOUSKI: Are you asking the duration of how long we actually need it? To tell you the truth, I do not know.

MEMBER BANERJEE: Is it short? That's what I wondered.

MR. WOJCHOUSKI: Shorter. When we

originally licensed, we were at 1,675 megawatts-thermal. And our current license is at 1,775. So when we went to transition, we went ahead and actually increased it.

For Montecello, our original design was that we put it in a our tech spec basis that we needed containment accident pressure, saying that for small periods of time you would need that. It was not quantified. I never did see the analysis from the late '60s that specified that.

In 1997, when we put in our suction strainers, we went ahead and also requested review and approval for containment accident pressure at Montecello. That was a time when we formally did the calculations and submitted them to the staff. They got reviewed and approved at that time. So that was the basis of that 1,775.

Prior to that, it was noted that we had needed it within our basis. I'm not sure if all BWRs are in the same situation, but I am sure all of the designs are similar. And they would probably have needed it based on what their peak suppression pool temperature at the time was calculated to become.

MEMBER BANERJEE: But these are Montecello was at -- the pump's not that deep in --

MR. WOJCHOUSKI: Right. The single-stage pumps, they're in corner rooms off of the torus main room. They are not in pits. They are not multi-stage.

MEMBER BANERJEE: Thanks.

MR. WOJCHOUSKI: Vermont Yankee is the same design. Duane Arnold is the same design. Many of the Mark 1's are of that same design.

The main function of the primary containment, as you know, is to be a barrier for the release of fission products from the reactor to secondary containment.

And the other function of it is to reactively reduce the pressure inside the containment, in which once you have a LOCA inside the drywell, it will force the non-condensibles and the steam down the vent lines through the vent header and down the downcomers.

Downcomers are submerged underneath water. So as the condensibles are forced through the water, they'll condense, reducing the overall pressure of the whole containment.

DR. WALLIS: Now, you said the containment is a barrier. And the fuel cladding is also a barrier and so on. And maybe this is a time to say that with

CAP, you've got one barrier dependent on the other barrier.

So this raises a question of defense in depth and how you evaluate this independent barrier idea. Sometime we're going to get to that, I guess, with the --

MR. WOJCHOUSKI: We will get to that. We have specific slides in which we went ahead and analyzed what happens if your failure, single failure, that you're doing is a containment itself. So that's towards the very end of the presentation we'll be covering that. And if you have additional questions at that time, we would be happy to go ahead and address them.

Methodology that's discussed within the Topical report. Deterministic calculation of NPSHa without containment accident pressure, it uses conservative assumptions for DBA LOCA and normal assumptions for special events. And it determines the wetwell pressure comparing the NPSHa to NPSHr.

Statistical evaluation is NPSHa without containment accident pressure. If NPSHa is lower than NPSHr, then this goes and provides a realistic evaluation of the event in support of containment accident pressure requests based on the deterministic calculations.

MEMBER ABDEL-KHALIK: Now, why would you need the wetwell pressure if you are not taking credit for the containment accident pressure in this first bullet?

MR. WOJCHOUSKI: What you normally do is go ahead and do the calculation without crediting any containment accident pressure on it. And you find out if your NPSHa is above your NPSHr.

MEMBER ABDEL-KHALIK: Well --

MR. WOJCHOUSKI: If that's the case, then you don't need any containment accident pressure.

MEMBER ABDEL-KHALIK: To calculate NPSHa without taking credit for the containment accident pressure, do you need the wetwell pressure or do you just need the wetwell temperature?

MR. WOJCHOUSKI: For doing that, you go ahead and assume that the wetwell pressure is atmospheric.

MEMBER ABDEL-KHALIK: When you say, "determine the wetwell pressure," what does that mean?

MR. WOJCHOUSKI: What you do for determining the wetwell pressure is if you go ahead and do your calculations and have NPSHa above NPSHr, you don't need any -- if you find out that you're beneath NPSHr, you go ahead and take some of the credit of the wetwell pressure. And how much you use is how much is needed to make NPSHa equal NPSHr.

MEMBER ABDEL-KHALIK: But we're not converging.

MR. WOJCHOUSKI: Okay. Good.

MEMBER ABDEL-KHALIK: Go ahead and continue. What also happens with the methodology?

MR. WOJCHOUSKI: What happens if you have NPSHa lower than NPSHr, you go ahead and also statistically go ahead and do some calculations with it and find out more realistically what the needed pressure would be.

If you find out that, even with containment accident pressure, you do not have enough NPSHa to equal NPSHr, then you need to go ahead and evaluate alternate means, which basically means they have to go ahead and start working with the pumps and vendors and see what other things that you can actually do to accommodate the pumps working for that.

MEMBER ABDEL-KHALIK: So in big picture terms, you enter this last scenario if and only if the entire totality of available accident pressure credit to be taken is insufficient to provide what you need in terms of NPSH?

MR. WOJCHOUSKI: This is correct. And we have never seen an example that we really need to go that far yet, but we have a methodology in which if that case comes up, that we can go ahead and continue the dialogue.

MEMBER ABDEL-KHALIK: Okay. So you enter bullet 3 or the third scenario when you have absolutely no margin for NPSH, even when you use realistic calculations?

MR. WOJCHOUSKI: This is true. So, even if you're using realistic calculations and your NPSHa is less than NPSHr, you go ahead and have to do another method.

MEMBER ABDEL-KHALIK: Do you think this is prudent?

MR. WOJCHOUSKI: If you can go ahead and do a different methodology, like adding another heat exchanger or something else --

MEMBER ABDEL-KHALIK: No. At point 2. Before you enter point 3. If you are right at the point where you are actually using up all available containment accident pressure credit with no margin left, do you think that's prudent?

MR. WOJCHOUSKI: That would be point 3.

MEMBER ABDEL-KHALIK: Just on the margin

before you enter point 3, just on the boundary between 2 and 3.

MR. CROWTHERS: I think, if I may, when we get into the statistical analysis description, you will hear that there is some -- even though it is statistical and it is more realistic, there is still some conservatism built into that methodology.

Maybe we ought to wait to see how that goes and then ask the questions.

MEMBER ARMIJO: I thought that after you did your first step, conservative assumption DBA LOCA, nominal assumptions, and all of that, after that first step, you would do an evaluation of whether there were some changes to the pumps or other systems and determine whether it was practical or not.

So there must have been -- it bothers me that you're not looking at the alternate of an engineering fix to, let's say, pumps can't deliver what is needed. You look at that as a last resort, rather than as an initial look that says, "Hey, look. We can do something to upgrade these pumps or if worse comes to worst, we'll get some better pumps."

We have never heard, at least I haven't heard, on this Subcommittee any kind of discussion of the extent to which you would go to upgrade the plant so that it can deliver the power that you need without compromising the safety system.

That is where I am at philosophically. Your calculations may turn out that there is margin all over the place. And that would change my mind. But right now I just think you're doing things sort of backwards.

MR. WOJCHOUSKI: In order to go ahead and put together the licensing submittal to the NRC, one of the things that you have to do within that is go ahead and say why you cannot reasonably go ahead and modify the plant. If it's small modifications, that will be done by the utilities to go ahead and get the extra margin.

If it comes out like for Montecello, we were talking earlier about deep well pumps. Montecello, we have several corner rooms in which we have two RHR pumps and a core spray pump. It's got approximately 12 feet of structural concrete with lots of rebar underneath it.

In order to go ahead and replace existing pumps with the deep well pumps, you're digging through 12 feet of concrete then beneath that. And you'd have to analyze the structural impact on the building itself if you're going to go ahead and try to perform

--

MEMBER ARMIJO: I can understand there is a cost and it could be a great cost, but then there is also benefit. In a big power uprate, there is a big benefit, too. So if it was a generator you had to replace to get more power out of the plant, you wouldn't hesitate.

But if it's this pump, it seems like it's -- I don't know. It just seems like the sequence of considerations is wrong. But that's prejudging. So I'll just be --

MEMBER BANERJEE: Just to carry on Sam's thoughts, you entered that thought right at the end. You say, "Oh, now maybe we can add another heat exchanger or something." Why do then? Why not earlier? You're doing this uprate. You don't do this without an uprate. So why don't you look at that earlier?

MR. WOJCHOUSKI: You can do it. You can be here asking for containment accident pressure whether you have an uprate or not an uprate.

MEMBER BANERJEE: You said you entered this last point where you stopped to look for another heat exchanger or something. Unless I've got you wrong, after you show that this --

CHAIR SHACK: It's your last resort, not your first resort.

MEMBER BANERJEE: Yes, your last, not your first.

MR. DENNIG: Alan, this is Bob Dennig, Chief SCVP in NRR. In terms of the terminology and when you do things and don't do things and what the credit is, I think it might be useful to quickly go to your slide 21 or 22 and talk about the relationship of those plots to atmospheric and at what point or under what circumstance do you do the statistical analysis and so on and make it more concrete. Would that make sense?

MR. WOJCHOUSKI: We can jump to the end of the presentation.

CHAIR SHACK: Yes. I think the terminology is a little bit twisted. And I think that might help. If it doesn't help with that, the guidance from the staff says it cannot be practically altered. And there's no guidance in the BWR Owners' Group document that really addresses that question.

MR. WOJCHOUSKI: I believe it is in there. I believe it goes ahead and says that you're supposed to go ahead and demonstrate that it's not practically --

CHAIR SHACK: A particular example, why can't you replace the pumps with pumps that can pump it to replace fluid?

MR. CROWTHERS: You could, but the Owners' Group is not going to prescribe that, right? We're trying to provide generic methodology to go through and work your way through this issue. That's really going to be up to each licensee to make those kinds of decisions whether they do mods, what kind of mods they might be, et cetera.

MR. WOJCHOUSKI: So this lays a prescription on how to do your calculations, how to do statistical calculations, and what to go ahead and look at for possible modifications.

MEMBER ABDEL-KHALIK: But I think that the basic underlying question is Reg Guide 1.82, rev. 3 position, 1.3.1.2 for PWRs, and position 2.1.1.2 for BWRs state that for operating reactors for which the design cannot be practicably altered, it is acceptable to use containment accident pressure greater than a containment pressure prior to the accident, greater than atmospheric.

The question is, do you believe this grandfathering clause remains applicable, regardless of what changes the licensee may decide to make to the plant, including power uprates?

MR. WOJCHOUSKI: The plants were designed and needed containment accident pressure before power uprates. And there's no reason why they shouldn't be allowed to have containment accident pressure after uprates.

The main thing that you're doing with the power uprates as you are changing the temperature of the suppression pool water, as that goes up, your vapor pressure goes up. And you need more --

MEMBER ABDEL-KHALIK: I think you gave your answer. And I guess we'll ask the same question for the staff, whether this grandfathering applies, regardless of what changes the licensee may elect to take or make to the plants. Thank you.

MR. WOJCHOUSKI: okay. I think we'll just pop back to the slide again. Next. Okay.

So the methodology, do deterministic calculations, do statistical calculations to go ahead and show the margin in it.

MEMBER RAY: Okay. One more time. It's been said, but I'm going to say it also. Why don't you reverse the sequence of the last step and the second step? Just if you can say that in simple terms like he said, which is not the business of the Owners'

Group to do that, if that's your answer, fine. Is that your answer?

MR. WOJCHOUSKI: Yes.

MEMBER RAY: Okay. Fine. It's just not the business of the Owners' Group to do it. It's the business of our licensees to do it.

MR. WOJCHOUSKI: And that's part of the methodology that they have to consider when they are putting their application together.

MEMBER RAY: Yes. I hear you.

MR. WOJCHOUSKI: NPSH overview. How the Topical report went ahead and calculating net positive section had available is broken down for simplicity into just two terms: Hww and Hpl. Go ahead and look at the parentheses underneath it. Hww is basically Pww, which is a wetwell airspace pressure, minus the vapor pressure, times 144 over the density of the suppression pool water. That is basically Hww. We went ahead and organized it this way because those terms are easy to get out of the containment analysis that is normally performed by General Electric Hitachi for us.

The other terms, the Pll happens to be with the height of the pump and the losses due to suction strainers and due to suction piping. Those are typically gone ahead and calculated up by the utilities themselves.

DR. WALLIS: Can I ask you about that suction strainer loss?

MR. WOJCHOUSKI: Sure.

DR. WALLIS: I think in the document it says you use NEDO-32686A, which is a document from 1998 about how to calculate suction strainer head loss. And I thought we knew a lot more now about suction strainer head loss than we did in 1998. We knew a lot more about the uncertainties in calculating it. I wonder if it's appropriate to use such an old document for what could be an important element in the head loss.

MR. WOJCHOUSKI: Right now that is our licensing basis method of calculation. That's what Montecello's license is based on.

DR. WALLIS: Is it realistic or conservative or what? It calculates a head loss, but there are big uncertainties about that head loss presumably from our experience with head losses.

MR. WOJCHOUSKI: There is. And each utility has gone ahead and addressed those on their own basis. For Montecello, I'll give you a couple of examples just to try to answer your question.

Montecello, we went ahead and put in suction strainers. In order to go ahead and add additional conservatism when we were doing the prototype heat exchangers, we took 15 square feet of plastic and taped it on the outside of the strainer before we went ahead and dumped all the debris, paint chips, iron oxide, and NUCON insulation into the slurry to come up with what our head losses would be with the prototype testing.

We went ahead and also -- conservatively the documentation says that if you have gone ahead and measured how much accumulation of sludge basically, iron oxide off your piping, if you have not gone ahead and measured that, you are supposed to assume 300 pounds per year actual accumulation in your calculations. It says that if you have gone ahead and measured it, that you could probably go -- you could use 150 pounds per year accumulation.

Montecello measured ours. And we had like 76 pounds. So there is a lot of conservatism in how much debris is being generated and used on all the suction strainers.

DR. WALLIS: So I think you're saying you don't just rely on some old method. You actually do new experiments?

MR. WOJCHOUSKI: At the time that we went ahead and installed the suction strainers, which was in 1997, that methodology was new. We went ahead and did our testing according to the methodology.

DR. WALLIS: Do you recommend that all utilities do new testing, then, or do you recommend they use this old document?

MR. WOJCHOUSKI: For NPSH, what we're recommending in the licensing Topical report is that you use your current licensing basis. If that changes in the near future, that is going to be required to be something different, that is what we will have to use.

But right now whatever their current licensing basis is is how you go ahead and calculate what your suction strainer --

MR. CROWTHERS: There is a separate effort, separate committee, separate activity, looking at BWR strainers based on what's been --

DR. WALLIS: And this might have an influence on CAP.

MR. WOJCHOUSKI: And this is another reason why if that changes significantly, that some other utilities without going forward on power uprate may have to come back in and ask the staff for some additional containment accident pressure. And then they would be right into this methodology, as we stated here.

So it's not just power uprates. It could be outcome of suction strainer.

DR. WALLIS: So when you do your statistical analysis, do you vary the Hloss from the strainer in the statistical way?

MR. WOJCHOUSKI: No.

DR. WALLIS: No?

MR. WOJCHOUSKI: What is being changed on the equation statistically is the containment analysis.

MR. CROWTHERS: We'll get to that.

MR. WOJCHOUSKI: We'll be getting into that.

DR. WALLIS: And the third point is if this was a big term in your losses, this would be some place where you could make changes to the design which might be feasible and not too expensive compared with boring through 12 feet of concrete. You could change the strainers if that helped.

MR. WOJCHOUSKI: Strainers are as big as you can get in the whole --

DR. WALLIS: They are now?

MR. WOJCHOUSKI: They are now.

DR. WALLIS: They are now? Okay.

MR. WOJCHOUSKI: It's a huge term on the loss anyway.

DR. WALLIS: That will be interesting to know. Thank you.

MR. WOJCHOUSKI: Deterministic approach. The traditional conservative analysis that is being performed uses substantive inputs that are bounding for the containment initial conditions.

The resulting pool temperature response is maximized, and available head response is minimized. This approach will give a conservative assessment of NPSHa. This is what utilities have been using already.

Statistical approach. This is new. It takes credit for variabilities in the analysis inputs. The order the statistical method is applied, the input to variables is defined statistically and combined through a Monte Carlo process. Fifty-nine random draws are made from the corresponding probability distributions.

Containment pressure and temperature time histories are calculated for each of those 59 cases. This allows for more realistic NPSHa values and which can be used to quantify the conservatism in the deterministic analysis.

MEMBER BLEY: Why 59 cases?

MR. WOJCHOUSKI: Fifty-nine cases is the minimum number of cases that you need to come up with a 95 percent confidence level. If you did a lot more cases, you could come up with a 96 or 98 confidence level.

Ninety-five confidence level has been used since all of that has been established in other --

MEMBER BANERJEE: It is their peak clad temperature methodology.

MR. WOJCHOUSKI: For the deterministic approach, you either the maximum or the minimum values.

MEMBER BANERJEE: Excuse me. When you apply it to other problems, that presumes that you actually use a best estimate code to do the calculations.

MR. WOJCHOUSKI: We're not using best estimate code. SHEX is the code that has been used in the analysis here.

MEMBER BANERJEE: So the analogy is not exact, right, with what we do for other systems?

MR. CROWTHERS: We are not sure of the answer. Do you have the answer, Guanjan?

MR. LI: Yes. This is Guanjan Li from GE Hitachi. So, actually, in one of the responses to the NRC RAI we compare the CSAU methodology with our methodology. So this is step three, basically the phenomena identification and table. This is PIRT. We call it PIRT table.

So, actually, we didn't do that step because that one applies to the best estimate code. And the SHEX is simply try the code and to maximize temperature. So this is code. So we didn't do. And this is code uncertainty.

We agree with the NRC, actually. If you are going to use this best estimate code, like TRACG, to do this, this methodology. You'll have to quantify the code uncertainty.

MEMBER BANERJEE: I think that that's a clear answer, but if you do that, then we know what we're doing because you're using a CSAU methodology, which we all have developed, know, and love. And what you are doing here I don't really know.

So you have to clarify in detail what it means. You are not using a best estimate code. You haven't done a PIRT. So what are we doing?

MR. LI: The purpose of this LTR, actually, is to use the statistical method to demonstrate margin. So you are going to see, even if your own statistical methods, we still have a lot of conservatism that remains there.

So basically the steps, step 11, actually, inputs the parameters within that PIRT in the CSAU methodology. So this statistical method is demonstrating margin. If we remained some conservatism in our methodology, we think it is reasonable.

MEMBER BANERJEE: But we don't know. You know, that is the problem. People keep saying, "conservatism." We don't know what that means.

With the best estimate, could we know precisely what we mean?

MR. LOBEL: This is Richard Lobel from the staff. Could I address that?

MEMBER BANERJEE: Do you want to address it now or do you want to --

MR. LOBEL: In my presentation, I am going to show a comparison of the SHEX code, the code that GEH uses, with the GOTHIC code, both using the same, basically the same, input. And I can show you a comparison of pressures and temperatures between a more realistic code and the SHEX code.

MEMBER BANERJEE: Okay. We can defer that if you like.

MEMBER ABDEL-KHALIK: But, just for the record, has SHEX ever been formally evaluated by the staff?

MR. LOBEL: SHEX has been used for years in licensing calculations, but we have never written a formal SER approving it.

MEMBER ABDEL-KHALIK: Thank you.

DR. WALLIS: This 95/95 presumably comes from the NRC. It's nothing that you claim. It's not something that you put forward. It's something that you were told to assume, right?

MR. WOJCHOUSKI: It was a standard approach that has been used previously. It was reasonable.

DR. WALLIS: Something else, right?

MR. WOJCHOUSKI: And we --

DR. WALLIS: There is nothing magical about 95/95. There are some things which you might want to be more sure of than 95 percent. I mean, five percent of something, probability of something, going wrong is tolerable in some aspects of LOCAs and not in other aspects of LOCAs.

So maybe when the staff gets up there, we should say 95/95 isn't a magic formula that you can apply to everything because sometimes you want to be more certain, sometimes you want to be less certain depending on how severe the consequences are.

It's not really a question for you, but you're just taking this as given, right?

MR. WOJCHOUSKI: I'm taking this as an acceptable method of doing the statistical. The statistical approach input parameters can be statistically defined and identified and will not necessarily be at their extremes, your maximum, your minimum values at the same time. The remaining inputs are identical to those used in a deterministic approach.

The statistical approach, these are the different input parameters that can be statistically defined. You can go ahead and do initial reactor power, decay heat, initial suppression pool temperature, surface water temperature, basically the river water temperature, heat sink, the initial suppression pool volume, the initial drywell temperature, the RHR heat exchanger, heat removal capability, initial drywell pressure, wetwell pressure, and the containment leakage rate. All those can be statistically defined and put within the statistical model.

DR. WALLIS: Do you want to tell us which are most important? As I remember from one of our presentations earlier, the heat sink temperature is important.

I mean, the river may be in very extreme conditions because it's at 95 degrees Fahrenheit but almost never. And that makes a big difference to the answer.

Isn't that the one that's the most important?

MR. WOJCHOUSKI: Montecello, our ultimate heat sink design temperature is 90 degrees. We never got up to that temperature. We got to 87 and a half degrees. I think we reached that twice over the life of the plant for the last 40 years.

Montecello also -- seeing as how we are up in the north, about half the year, we have very cold river water. Part of it is that we've got ice on some of it coming up.

DR. WALLIS: In the north?

MR. WOJCHOUSKI: So average temperature is in the mid 50s. And what we go ahead and do for these particular different inputs is we take five years' worth of data, put them in different temperature bins if you're talking river water, and then find out how much time each one of those different bins is accumulated, comes up with an exceedance probability.

Once those exceedance probabilities are developed, you go ahead and use the random number generator. You go ahead and pick the values for the 59 different cases. So that's how the statistical --

DR. WALLIS: I understand that. I was just saying you didn't give us an order of magnitude which one is most important. As I remember, the surface --

MR. WOJCHOUSKI: Surface water was one of the top ones on it. Your decay value is another important one. I don't remember within the Topical report. We went ahead and did a sensitivity study on varying all of these different parameters and shows what the net effect was on --

MR. CROWTHERS: Can you talk to that, Guanjan?

MR. LI: Yes. Yes, you're right. The surface water temperature, it's the most important one parameter. Actually, in our RHR table 3-1, we did a sensitivity study. So if you change the surface water temperature by 20 degrees, surface temperature changes 10 degrees.

DR. WALLIS: So a very thing to do without changing the plant at all is to decrease your power on the day when the roof is very hot. Isn't that something you should consider as an alternative?

MR. WOJCHOUSKI: That was thought of. The problem with that is it's decay heat. And what has been your power history? So that becomes an issue with it also.

MEMBER ARMIJO: You picked the range. Does the guidance provide the range of initial reactor power or is that at the discretion of the individual utility? What is that range for? Is it 100 percent plus/minus a couple --

MR. WOJCHOUSKI: Deterministically, if you do a deterministic evaluation, you use 102 percent of your reactor thermal power. If you're doing a statistical approach, it uses a normal distribution at the 100 percent mark.

MEMBER ARMIJO: So what is the range? From what to what? Ninety to 102, something like that?

MR. LI: Yes, yes.

MR. WOJCHOUSKI: We've mentioned this a little but. Statistical approach combines the variables and input parameters through a Monte Carlo process. Random draws are made from corresponding probability distributions in order to determine the input values.

Calculations of containment responses with one set of those random draws input values represents one trial of statistical process. So you do that 59 times. So you have 59 independent calculations of containment response in order to come up with a 95 percent probability, 95 percent confidence level.

MEMBER BANERJEE: The first line I was just reading there, "Consistent with TRACG AOO." What is that? You show that the method is acceptable for this?

MR. WOJCHOUSKI: It shows that it's been applied other places.

MEMBER BANERJEE: Okay.

CHAIR SHACK: It just means he's following the order statistics. That's all.

MR. WOJCHOUSKI: That is all it really means and just gave a reference to it.

Other statistical approach, the outputs that are needed for NPSHa is the pool temperature, the wetwell airspace pressure, and the pool volume. Those are calculated with SHEX. And those are used on a time history basis to drive what your NPSHa requirements are.

Based on these outputs, calculation of the term Hww as a function of time for each one of the 59 different calculations are obtained. And you obtain the minimal values of Hww as a function of time. The resulting minimum values are used as a magnified percent value.

CHAIR SHACK: It just comes back to that question that Sanjoy raised about the code. I mean, we're not dealing with the uncertainty in the model here. We're dealing only with the parameter uncertainty.

From my mind, that's okay if I'm convinced that the modeling errors in the code are on the conservative side. And you made the comment that it's conservative as far as temperature goes, but it's not the temperature that I'm worried about here.

It's pressure minus vapor pressure. It's the head. So do you have any demonstration that SHEX is calculating that quantity conservatively?

MR. LI: Yes. Actually, we have talked here this Hww. So that term --

CHAIR SHACK: Right. That's the --

MR. LI: -- actually term that --

CHAIR SHACK: You made the comment about temperature before. And temperature isn't the parameter I am interested in. It's Hww.

MR. LI: Yes. It's Hww. For example, in our statistical calculation, where you assume a drywell/wetwell relative humidity of 100 percent, that one minimizes drywell and wetwell pressure.

So probably not in this version of our presentation, in our LTRs, we issue the wetwell comparisons. You will see.

So basically one for the parameters we worry the other parameters will remain the same as deterministic.

MEMBER BANERJEE: I think we need to at some point review this whole business of SHEX seriously. But it's different when we're dealing with something like TRACG, which has been scrutinized and looked at and we understand what the uncertainties are, they have been compared to experiments very widely. But here it is quite a different matter.

Let's pursue this when we discuss the codes, come back to this. We table this as an item.

MR. WOJCHOUSKI: Special events. NPSH methodology for special events is also presented in the Topical report. It briefly describes what each of the special events are, the similarities and contrasts between the DBA LOCA, NPSH analysis, and identifies conservatisms in the special events NPSH valuations.

Topical report did not do any analysis of the special events. You're using similar methodology to what was presented for the LOCA, which just discusses --

DR. WALLIS: I am a bit puzzled by that. I read that. And it says for special events, which would be ATWS and SBO and so on, it says, "If COP is required, special consideration is given to potentially non-conservative modeling assumptions." Well, what does that mean?

MR. WOJCHOUSKI: Repeat your question again.

DR. WALLIS: In this report of your, it says, "For special events, each one of the special events," it says, "if COP is required," --

MR. WOJCHOUSKI: Right.

DR. WALLIS: I'm just quoting now.

-- "special consideration is given to potentially non-conservative modeling assumptions." I don't know what that means. I don't know what it implies that you now do. If you need COP, what does special consideration mean?

MEMBER ABDEL-KHALIK: You already are in the hole. That is the question.

MR. WOJCHOUSKI: Yes.

MEMBER ABDEL-KHALIK: So you're going back to look at non-conservative assumptions to put you deeper in the hole?

DR. WALLIS: Are you trying to make them conservative or what are you doing?

MR. CROWTHERS: We'll have to get back to you. We'll have to go look at the context of where that statement is unless you guys can answer that. No? Okay. We'll get back to you on this.

MR. WOJCHOUSKI: The deterministic approach utilizes nominal input values will be used in the calculation for NPSHa for a special event. Should the approach not satisfactorily show that NPSHa minus NPSHr is greater than zero, then the statistical approach utilizing the mean output values will be used to show that the expected realistic response to the event.

DR. WALLIS: Do you have experience with doing that? I'm not sure if the mean value from the statistics is greater or less than the nominal value.

MR. WOJCHOUSKI: The mean value of the statistical report -- statistics, you have the minimum, the maximum, and the mean.

DR. WALLIS: Yes. But you're using it

when nominal values don't work. And I'm not sure if that makes it better or worse.

MR. LOBEL: This is Richard Lobel from the staff. In my presentation, I have some comparisons of statistical analysis, realistic analysis, and conservative analysis.

DR. WALLIS: Under nominal?

MR. LOBEL: Well, what I am calling realistic is what they're calling nominal pretty much. Again, it's calculated with GOTHIC, but we did three types of calculations. We did the conservative, typical conservative.

We did a realistic where we tried to make everything as realistic as we could except for the things like surface water temperature that it's hard to get a realistic value of and realistic, conservative, and statistical. And I'll show the comparisons.

CHAIR SHACK: By "realistic value" for a parameter, you mean an estimated mean value?

MR. LOBEL: It turns out, yes, it's almost exactly that.

CHAIR SHACK: Well, no. I know. There's a statistical mean for the discombined distribution. There's also the individual parameter means. And what you're saying is that when you calculate using the mean values of the distribution, you get something that sort of looks like the mean of the statistical?

MR. LOBEL: No. What I'm talking about is what we did was we ran the 59 cases and took the mean of the 59 cases.

CHAIR SHACK: Just when anybody says a "nominal value," I always want to know what the nominal value is.

DR. WALLIS: What is it? Is the nominal --

CHAIR SHACK: Is the nominal value the mean? You know, that's -- or what is it if it isn't the mean?

DR. WALLIS: What is it?

MR. WOJCHOUSKI: What we will have done for our special events is used either bounding numbers the same as deterministically and occasionally a few of the numbers. Instead of using an absolute bounding number, we'll do it about the 95 percent confidence level on that particular parameter.

So typically we do not go ahead and change all of the numbers on the statistical or all the inputs to a nominal average value. It's normally using the same deterministic. Only one or two of the different variables will go ahead and be put at a 95 percent value.

Does that answer your question a little bit better, how we actually do the --

CHAIR SHACK: No. Maybe you ought to tell me how you get the distributions of these parameters.

MR. WOJCHOUSKI: Input parameters, what we did for the Montecello and the statistical, we took five years worth of our plan data. You can come up with a mean on it. You can come up with a standard deviation on it. And you can come up with a 95 percent confidence level of that particular input variable.

DR. WALLIS: And what is the nominal value?

MR. WOJCHOUSKI: The nominal value is a value that isn't bounding that you select to put as an input.

MR. CROWTHERS: It is realistic, right?

MR. WOJCHOUSKI: It is typically more realistic than the bounding deterministic.

MEMBER RYAN: So how does the nominal value relate to the mean of the distribution of your data that you just described? Is it the same?

MR. WOJCHOUSKI: Typically you do not just pit the mean of that distribution. You'll pick a 95 percent confidence level on it. So it's an upper bound.

MEMBER RYAN: Not always.

MR. WOJCHOUSKI: I do not know exactly all the inputs on those special events that we have used. I have done certain calculations of those. You have to go ahead and have a nominal value, whatever you call a nominal values. You have to be conservative enough to have a defendable why that is a good number to use within your calculations.

DR. WALLIS: I think what you are saying is the nominal value is always more conservative than using the mean.

MR. WOJCHOUSKI: Yes.

DR. WALLIS: That's true?

MR. WOJCHOUSKI: That's true.

DR. WALLIS: I thought that's what you wanted to say.

MEMBER RYAN: But by how much?

MR. WOJCHOUSKI: Going on, example of plant analysis. This is where we took five years of data was used for developing the exceedance probability distribution for each one of the different parameters that were defined statistically.

Containment analysis --

DR. WALLIS: No. Wait a minute. Excuse me. Five years of data on river water temperature, there must be some action you take if it's an unusual year when the river water gets warmer than it's been for five years. You don't do anything special then?

MR. WOJCHOUSKI: We take the plant data as it is recorded.

DR. WALLIS: Yes, but five years' data is not very reliable for that sort of environmental parameter, is it?

MR. WOJCHOUSKI: We went ahead and plotted 10 years and 15 years.

DR. WALLIS: El Ninos and things are cycles which are longer than five years that affect --

MR. WOJCHOUSKI: What we are trying to define is a methodology of how you go ahead and come up with an exceedance probability --

DR. WALLIS: I understand that.

MR. WOJCHOUSKI: Five years seemed like a very reasonable time to go back.

DR. WALLIS: I understand that. But I know the river water temperatures is a very important lever in determining CAP. So if you're running Montecello, which I agree is in the north, there may be some time when the river water temperature gets above your specs. What do you do then?

MR. WOJCHOUSKI: If it's above your open heat sink requirement --

DR. WALLIS: Right.

MR. WOJCHOUSKI: -- tech specs will have you shut down.

DR. WALLIS: You actually shut down? Okay. That's --

MR. WOJCHOUSKI: Tech specs on --

DR. WALLIS: That's a good answer. Thank you. Okay.

MR. WOJCHOUSKI: The next one that we went ahead and did is did three different scenarios. One is short-term, which is less than 600 seconds and using a single limiting failure; the long-term analysis, containment analysis, which is greater than 600 seconds, using a different limiting single failure. And the last scenario that we did is containment integrity was not credited. What happens if you lost containment integrity?

Each one of these different scenarios was done two ways: the deterministic approach, which is a typical licensing basis; and the statistical approach, which is the Monte Carlo which we have been talking about.

This represents the suppression pool temperature for the DBA LOCA with a diesel generator failure. This is our long-term results, greater than 600 seconds, in which a single failure is the loss of a diesel generator.

The reason why that is considered the worst failure is that you lose one division of your low-pressure ECCS. And you only have one division remaining for you.

Part of the other assumptions for the DBA LOCA is that you lost off-site power. So you have one diesel operating, two RHR pumps and one core spray pump to address this scenario.

You can see here from the different curves the deterministic calculation showed the peak suppression pool temperatures as a function of time. That's your line number 4.

Out of statistical analysis, you have lines 1, 2, and 3, the maximum, the mean, and the minimum. And it just shows a comparison of what your expected suppression pool temperatures are doing those different methodologies.

This slide shows long-term again, greater than 600 seconds. And it shows what happens if you consider that you lost your containment. This scenario is different than a design basis LOCA in that you're not assuming that you have a loss of your other diesel.

So you have both trains of low pressure uses GS. You have two RHR heat exchangers up in operation. And you have a full complement. We wanted to demonstrate and show you what that looked like also. We'll have the plots, other plots other than this, shortly.

As you can see here, it goes ahead and shows you that what the deterministic model shows is line number 4. If you compare to the earlier slide, you can see that, instead of being above 200 degrees, this is around 170 degrees, much lower. That's because of the extra heat exchangers.

DR. WALLIS: What effect does this have on NPSH?

MR. WOJCHOUSKI: Well, the slide or two will show you right there.

DR. WALLIS: Are you going to show us your --

MR. WOJCHOUSKI: The main driver on NPSH is a suppression pool temperature.

DR. WALLIS: Are you going to show us that with 95/95, you don't need CAP at all?

MR. WOJCHOUSKI: With 95/95, you don't need CAP at all. That's correct.

DR. WALLIS: And with existing plants with existing power levels?

MR. WOJCHOUSKI: Existing plants, existing power levels. This particular analysis was done at Montecello's EPU power level.

Going long term deterministically --

DR. WALLIS: Did VY do an analysis like that?

MR. WOJCHOUSKI: I'm unsure. Maybe, Guanjan, do you know what VY did, analysis similar? I don't think they did the statistical analysis.

MR. LI: I am sorry. I don't know this.

MR. LOBEL: This is Richard Lobel from the staff. VY didn't do exactly this kind of analysis, but they did sensitivity studies that were under appendix B that showed that with just relieving some of the conservative assumptions but not all, they didn't need containment accident pressure.

DR. WALLIS: I remember that. In fact, we wrote a report where we said we would like to see a statistical analysis or some of us did. Have they done any statistical analysis since that? Do you know?

MR. LOBEL: I don't believe so.

DR. WALLIS: Okay.

MR. WOJCHOUSKI: This curve shows the results deterministically of what you expect for the wetwell pressure. And what the other line is, the RHR wetwell pressure required deterministically.

What that line represents, the black line represents, what wetwell pressure is needed to have NPSHa equal NPSHr. So you actually can go ahead and look where the peak is. There is the margin between that and what your calculated wetwell pressure is.

MEMBER ABDEL-KHALIK: For this particular case?

MR. WOJCHOUSKI: For this particular case.

DR. WALLIS: So the margin is how many psi here, something like six psi or something?

MR. WOJCHOUSKI: Six to seven psi. And you need approximately six psi, too.

DR. WALLIS: Does that mean, what's his name, the pump man's criteria, Budris? Budris recommended certain margins. Does that make his margins?

MR. WOJCHOUSKI: That I'm unsure of.

DR. WALLIS: Unsure of.

CHAIR SHACK: You are under 15 percent.

DR. WALLIS: I think it does.

CHAIR SHACK: Yes.

DR. WALLIS: I think it does.

MR. WOJCHOUSKI: This is a comparison of containment accident pressure required for the RHR pumps to do DBA LOCA, a comparison of what it is deterministically and what you would need statistically. You can see that if you do the statistical approach on here, that it's a lot less.

DR. WALLIS: Of course, the pressures varies statistically, too.

MR. WOJCHOUSKI: Pressure is different. And it's lower also.

This shows a core spray DBA LOCA, a comparison of its deterministic and its statistical approach.

This shows you the RHR pumps without the containment integrity. If you do it deterministically, in which you are using bounding inputs or river temperature, initial suppression pool temperature, and those sorts of things, it shows you that with all of your complement of RHR pumps, that deterministically you would need some containment accident pressure to have NPSHa equal --

DR. WALLIS: This is all for Montecello?

MR. WOJCHOUSKI: This is Montecello's data.

DR. WALLIS: What's the elevation of Montecello?

MR. WOJCHOUSKI: Ninety thirty-five.

DR. WALLIS: So the atmospheric pressure is --

MR. WOJCHOUSKI: What we're doing here is conservative. What you have on here is 14.26 is used for --

DR. WALLIS: Okay. Thank you.

MR. WOJCHOUSKI: -- is conservatively defined as the lowest monthly average that we have seen in umpteen years.

DR. WALLIS: Okay.

MR. WOJCHOUSKI: So what you also have on here is statistical. And statistical as you look at that shows you that you're underneath what your atmospheric pressure is. So you're --

DR. WALLIS: Yes.

MR. WOJCHOUSKI: You do not need containment at pressure if you lose your containment. And that was your major single failure.

DR. WALLIS: So is this what is done now?

Is it usual for plants to use a minimum atmospheric pressure for this calculation?

MR. WOJCHOUSKI: I am not sure what everybody else has used, whether they used 14.7. It's just how this is our licensing basis. We do conservative assumptions.

One of the assumptions is, what is your atmospheric pressure? Montecello uses 14.26 as a conservative number. That just demonstrates one of the other conservatisms that we are using. If you use 14.7, just move the line up.

Core spray, similar results.

DR. WALLIS: It's interesting because the difference between 14.3 and 15.3 on some of these curves would make a difference.

MR. WOJCHOUSKI: That's how close they are.

So, in closing, the Topical report goes ahead and tries to provide a methodology to the utilities on how to do the calculations for requesting containment accident pressure. It provides guidance on how to do deterministic calculations and how to go ahead and do statistical calculations to try to show you the margin inherent in the deterministic calculations.

MEMBER BLEY: Let me ask you, can you back up to either one of your two graphs, the last two you had? There you go.

You did the statistical calculations where you told us before. But on the earlier graphics, you presented a high, a bottom, and a mean. This is the mean, I assume.

MR. WOJCHOUSKI: This is the bottom. Minimum Hww was used for determining statistical.

MR. LI: This is a minimum.

MR. WOJCHOUSKI: Minimal.

MEMBER BLEY: This is the mean.

MR. WOJCHOUSKI: No.

MR. LI: Minimum.

MEMBER BLEY: No, no, no. Minimum. Okay.

MR. LI: That's right.

MEMBER BLEY: From the statistical calculation. Okay.

MEMBER ABDEL-KHALIK: Now, these statistical methods do not account for uncertainties in the required NPSH?

MR. WOJCHOUSKI: We have not addressed uncertainties in NPSHr at this time. What we had used for calculations is right out of what the vendor provided us for NPSHr.

MEMBER ABDEL-KHALIK: But you acknowledge that there are uncertainties in NPSHr; for example, you know, air content in the water. How would you handle that in this methodology?

MR. WOJCHOUSKI: What you would do on this methodology is you would go ahead and take your -- the staff will describe this in better detail, but you will go and take your NPSHr three percent. And, using that value, you will use NPSHr-effective, which addresses the uncertainties in it, and put that into your spreadsheet, instead of NPSH, three percent. And it will slightly raise everything up by those uncertainties.

MR. CROWTHERS: The staff will be talking about that.

DR. WALLIS: When you said this was the "minimum," I tie it to the maximum. It's the one that comes closest to the deterministic. It's the highest.

CHAIR SHACK: Yes. I hope it's the maximum.

MEMBER BANERJEE: But pursuing the question that --

DR. WALLIS: Can you just clarify that so we get it straight for the record that what you're showing us is the highest curve, isn't it, the ones that's closest to the --

MR. LI: Let me clarify. Yes, this is the maximum --

DR. WALLIS: Right.

MR. LI: -- containment overpressure you need.

DR. WALLIS: Right.

MR. LI: Actually, if you look at the curve Hww, we use Hww minimum. So the requirement then is maximum.

DR. WALLIS: But in this figure here, it is the maximum pressure.

MR. LI: Yes. It's the requirement. Maximum.

CHAIR SHACK: Can you also explain to me the difference between 19 and 20 for both containment accident pressure required the DBA LOCA for RHR pumps? And they're different.

MR. WOJCHOUSKI: Nineteen and 20.

CHAIR SHACK: And what's the difference between the two?

MR. WOJCHOUSKI: I am just trying to look to see. The curve itself, right here, the black curve, and this curve should be identical.

MEMBER BLEY: The bottom?

MR. WOJCHOUSKI: No. The top curve.

MEMBER BLEY: The top curve.

MR. WOJCHOUSKI: The top curve on here and --

CHAIR SHACK: That is what is required for the pump.

MR. WOJCHOUSKI: And this curve, the black one, are identical curves. The only difference between this particular one is all we're showing is the wetwell pressure on top of it to show the margin between what your calculated wetwell pressure is and what is required.

And then the next slide I am comparing that same curve to statistical.

MEMBER BROWN: So this was the wetwell pressure that results from the accident as you go through the accident transient and then you need the RHR pumps, right?

MR. WOJCHOUSKI: The red line is the wetwell pressure from the accident.

MEMBER BROWN: Okay.

MR. WOJCHOUSKI: And that is what is calculated underneath the containment analysis. And then the black line is how much of the wetwell pressure do you need to make NPSHa equal --

MEMBER BROWN: What is the difference between those two if what you -- I guess I didn't understand it. To me, this one says, "I've got enough wetwell pressure to ensure that I have enough NPSH to start" --

MR. WOJCHOUSKI: Right. That's the containment accident pressure.

CHAIR SHACK: And then I need a red curve on the next graph?

MR. WOJCHOUSKI: The red curve on the next graph would have been exactly the same as this graph. We could have put them both together. And then we could have also gone ahead and put the set of pressures out of statistical on top of that.

MEMBER BROWN: Okay. So all of these other curves you have just shown me are the additional margin that I presumably get out of having the statistical method?

MR. WOJCHOUSKI: Yes. The red line would be on all of them, what I got out of --

MEMBER BROWN: For the deterministic?

DR. WALLIS: Can we clarify the red line now in response to Charlie's question? The red line here is a conservative minimum containment pressure. What you calculate to determine whether the containment pressure needs its maximum limit is a different calculation, which is much higher. Isn't that true?

MR. WOJCHOUSKI: When we are doing the deterministic calculations, it is to minimize what the containment wetwell pressure will be.

DR. WALLIS: Minimize it.

MR. WOJCHOUSKI: It's going to minimize it. That's the deterministic.

DR. WALLIS: When you're doing the containment --

MR. WOJCHOUSKI: When we're doing a containment analysis for maximizing pressure, all the inputs are all flipped around to maximize it.

DR. WALLIS: Way up high.

MEMBER BROWN: This is going to make sure you don't break the containment.

MR. WOJCHOUSKI: That's correct.

DR. WALLIS: You don't do a statistical analysis of the containment pressure, though. You don't do a similar 50.59 run on --

MEMBER BROWN: So the way I would read these other curves, then, is if you have a containment breach, there is no integrity. Where you've got atmospheric and this defines how long you would have to and the magnitude of the delta that you have for the NPSH, it just -- I don't have any credit.

If I've lost credit, this is how long I would go with potentially no pumps, well, if they don't operate on the deterministic method.

MR. WOJCHOUSKI: On the deterministic method --

MEMBER BROWN: Well, it's the same for both, just a different method to do the calculation.

MR. WOJCHOUSKI: Right.

MEMBER BROWN: Let me go back.

MR. WOJCHOUSKI: Sure.

MEMBER BROWN: On slide 20, slide 20, that would tell me if I had no containment pressure, I had a breach. Then I've effectively got whatever the number of delta seconds is in there if I get a look at that 47 hours or so if you go through that, you would have had no cooling, if you have lost integrity to containment, you're above atmospheric now.

MR. WOJCHOUSKI: You're above atmospheric on here. What you have right now is you have a DBA LOCA going on. You have a loss of a diesel.

MEMBER BROWN: Yes.

MR. WOJCHOUSKI: And you're going to put on top of that the loss of containment integrity. So you've got beyond design basis. Underneath those conditions, deterministically if your pumps will not run with eating six extra pounds, --

MEMBER BROWN: Yes.

MR. WOJCHOUSKI: -- they would shut down.

MEMBER BROWN: You'd have no cooling.

MR. WOJCHOUSKI: And you'd have no cooling.

MEMBER BROWN: Okay. I like the litany that you went through, but --

MR. WOJCHOUSKI: That's just making sure that you have the right scenarios, what's going on with that.

MR. LOBEL: Let me say that is the conservative assumption that the pumps are going to shut down.

MR. WOJCHOUSKI: Right.

MR. LOBEL: The operator has instructions in his procedures -- tell me if I'm wrong -- that if the pumps are cavitating but he needs that flow to keep the core cool, he's going to keep trying to use those pumps. He's not going to turn off the pumps.

And it doesn't necessarily mean that the pumps aren't going to keep pumping. They may be vibrating. And they may not be delivering the flow that was considered in the safety analysis because we're beyond the safety analysis now. But it doesn't necessarily mean that there's no cooling anymore.

MEMBER BROWN: It just means you've got a loss of cooling. That's all. I recognize you might get some -- at some point the pumps don't --

MEMBER SIEBER: Sooner or later the pumps will fail.

MEMBER BROWN: You're going to lose it. So I'm just trying to make sure I understood the curves on the --

MR. WOJCHOUSKI: You also can go ahead -- these calculations are done at a specific flow rate. RHR is 4,000. If you go ahead and take operator action to throttle them back, your NPSHr goes down. You will need a little bit less.

MEMBER BROWN: Yes.

MR. WOJCHOUSKI: So you can do mitigating actions with that. EOPs may also direct you into adding water into the torus or something else, which will also mitigate this.

MEMBER BROWN: The valves, do you have throttle values on the --

MR. WOJCHOUSKI: Yes.

MEMBER BROWN: Are they manually or are

they remotely operable or what?

MR. WOJCHOUSKI: For RHR, this is from a control room.

MEMBER BROWN: Okay.

MEMBER BLEY: They are throttle. You can adjust.

MR. WOJCHOUSKI: They're throttle.

MEMBER BLEY: Is that in the procedures? I don't recall seeing that sort of operation in the procedures.

MR. WOJCHOUSKI: If you look in the EOPs, there are curves in there that go ahead and show you the operators are looking at their NPSH --

MEMBER BLEY: Yes.

MR. WOJCHOUSKI: -- and has one pump, two pumps, and what flow rates they are to be within the curves. And it directs them to watch for that, look for cavitation, and to direct the flow accordingly.

MEMBER BLEY: Okay. I didn't remember that.

MEMBER BROWN: Is it an individual throttle valve for each of the RHR pumps or is there just one where they --

MR. WOJCHOUSKI: For Montecello, we are the mixed-loop plant.

MEMBER BROWN: I don't know what that means. You'll have to tell me.

MR. WOJCHOUSKI: You can go into one loop. Let's say it's two loops: alpha and bravo loop. Logic will try to pick the unbroken loop. You have put all of your flow into the unbroken loop. And those have the ejection values are throttle-able because we have one on each path that is throttleable so that you can arrange it.

MEMBER BROWN: You can pick and choose?

MR. WOJCHOUSKI: You can pick and choose.

MEMBER BROWN: Yes.

MR. WOJCHOUSKI: Also, on our core spray, they also on their ejection valves have a throttleable valve. So --

MEMBER BROWN: Is that consistent on all of the Mark I plants?

MR. WOJCHOUSKI: Yes.

MEMBER BROWN: Thank you.

DR. WALLIS: Do you have performance curves for these pumps when they're throttled that you can appeal to then so the operator knows where he is and when he is throttling, he knows where he is in terms of NPSH?

MR. WOJCHOUSKI: Those are part of our

EOPs in which they have SPDS displays, which will show what the flow rate is on it and will show the bands that you have to be in. And as the flow rates change, it will show graphically where they are in or outside the band.

MEMBER BANERJEE: What is the pressure loss due to the debris? You had a previous slide which showed that you fully loaded it up with debris.

MR. WOJCHOUSKI: I would have to look through my calculation to break out the term for the debris.

MEMBER BANERJEE: Is it a very small amount or --

MR. WOJCHOUSKI: For Montecello, it's a pretty insignificant amount.

MEMBER BANERJEE: Less than psi?

MR. WOJCHOUSKI: I would have to look at my calculations and pull that value out. I just haven't looked at it to answer that question.

MEMBER BANERJEE: Can you just repeat what assumptions you made about the debris?

MR. WOJCHOUSKI: Okay. For debris which is used on this, Montecello, our particular one -- others may be different -- we assumed that we had 100 percent of our new kind installation become debris and be held up in the transportation going down into our torus. We also assumed that we had 300 pounds per year of accumulation of sludge, which is very conservative.

We also in our calculations have accounted for paint chips, in which when we went ahead and did our prototype testing, we created paint chips, had different sizes, different densities, or different weight thicknesses, and threw that all into the slurry to come up with the correlation for our calculations.

We also took on our strainer with -- I don't know if other people did this or not, but Montecello took a plastic sheet, 15 square feet, and taped it right onto the suction strainer to make that unavailable during the testing. And it's also within our calculations that that's accounted for that we lost that amount of surface area.

We put that in there for extraneous debris that could be inside of our containment that wasn't specifically accounted for.

MEMBER BANERJEE: Are these disc strainers or what sort of strainers?

MR. WOJCHOUSKI: Stacked disc strainers, stacked vertically in between a whole bay. And we have four of them. Montecello has a ring header on the outside of the torus with four penetrations going into the torus itself. At those penetrations on the inside of the torus is where we have --

MEMBER BANERJEE: The stacks?

MR. WOJCHOUSKI: -- the stacks, but they don't go vertically. They come up with a ram's head. And then they go horizontally right near the bottom of the bay.

MEMBER BANERJEE: How far below is the intake from the surface?

MR. WOJCHOUSKI: Just from memory, it's four, four and a half feet.

MEMBER BANERJEE: Give me the Froud number in rough terms.

MR. WOJCHOUSKI: Say it again.

MEMBER BANERJEE: You don't know the Froud number?

MR. WOJCHOUSKI: Sorry. I do not.

MEMBER BANERJEE: But the issue is vortexing. And you have looked at that, right?

MR. WOJCHOUSKI: We have looked at that. We have looked at approach velocities. There are lots of different factors that you have to go ahead and look at for determining this.

MEMBER BANERJEE: But the approach

velocity you are using, is it the approach velocity normal to the surface of the strainer or because they're stacked, is it -- because you know -- I would have to draw it for you, but this is a problem that a lot of them have that if you do single strainer tests, what ends up happening is that the debris really accumulates in the space between the disks.

The ultimate approach velocity is really the surface area on the outside of the disk is the normal to the surface strainer. Do you see what I am saying?

MEMBER SIEBER: Right.

MEMBER BANERJEE: Yes because the debris stacks into the little spaces in between. So the issue really then becomes what should be the approach velocity that you use. And I assume that you didn't the approach velocity based simply on the available surface area of the strainer?

MR. WOJCHOUSKI: That one I cannot answer for you right now.

MEMBER BANERJEE: It gives you a very different answer.

MR. WOJCHOUSKI: The sort of thing that I can relate to that is when we were doing the testing, instead of taking our paint chips and just putting into the pool, the only way to go ahead and have them have any effect is we had to dump them right on top of the strainer, which is physically above it, and dump them on there so that as they came down, they settled and landed on top of the strainer itself.

MEMBER BANERJEE: I would have to look at the design, but there is sort of an uncertainty associated with these pressure losses. Now, if the pressure loss is extremely small, it may not matter. But if it is significant, then you would have to put that sort of into the uncertainty analysis at some point.

Let's keep that in abeyance right now.

MR. WOJCHOUSKI: That's why --

MEMBER BANERJEE: Let's get an answer to the question, though, how large the pressure loss was that you had and maybe what the approach velocity was and the surface area. Give us all of those. Then I'll get a rough idea of what is going on then.

MR. WOJCHOUSKI: The loss of surface area and the approach velocity?

MEMBER BANERJEE: Yes, that you used. And did you use any number for air entrainment at all?

MR. WOJCHOUSKI: Not in these calculations.

MEMBER BANERJEE: Okay. Because air entrainment, of course, will have a significant effect on NPSH.

MEMBER SIEBER: Yes, it does.

MEMBER BANERJEE: It generally is very sensitive. Even if you get --

MEMBER SIEBER: One or two percent.

MEMBER BANERJEE: -- less than one percent, it will give you a huge difference in NPSH. So you used pure water?

MR. WOJCHOUSKI: Pure water?

MEMBER BANERJEE: Okay.

DR. WALLIS: So you have talked a lot about what is available for NPSH. Now, what is required? Are you using this three percent degradation in head value?

MR. WOJCHOUSKI: The Hydraulic Institute has the standard, saying that NPSHr is determined at the three percent. And that's what we used in these calculations.

DR. WALLIS: And this is from tests of the pumps themselves?

MR. WOJCHOUSKI: These are from tests of the pumps themselves. These pumps were built back in the '68-'69 time frame. They have tests that they did on our pumps. They were not NPSH three percent tests. They were demonstration tests that they meet an NPSH curve that the vendor provided us.

So when we started doing this work, we went back to Sulzer. They had pulled all of our data that we had. They have similar pumps that were made at the same time with the same type of models. They pulled that data together and came up with a three percent curve for Montecello and provided us that information.

DR. WALLIS: These pumps don't change at all with time? They don't corrode or something?

MR. WOJCHOUSKI: These pumps are used -- they're RHR pumps. They're used for shutdown cooling, which is about 30 days every 2 years. They're used for suppression pool cooling whenever we're doing testing on our hips in RCIC. And they're run through their surveillance tests themselves.

So the core sprays, they're only used for surveillance testing. And basically what we do on this is according to the IST program, we plop the differential pressure across the pumps. And we monitor and trend that. If we see a negative trend, we'll go ahead and do corrective action, such as rebuild the pump, replace the wear rings. So that's monitored.

MEMBER ABDEL-KHALIK: Let's just look at the graph that you have on this screen.

MR. WOJCHOUSKI: Sure.

MEMBER ABDEL-KHALIK: You have the deterministic calculation. And you have the statistical calculation. And this graph obviously is demonstrating that if you were to use the statistical calculation, you can demonstrate that the amount of containment accident pressure that you would need would be smaller and would be for shorter duration.

But if you put that in words, what the statistical calculation is telling you is that we are 95 percent confident that we will not require more than about 2 psi of containment overpressure for more than about 10 hours.

MR. WOJCHOUSKI: Okay.

MEMBER ABDEL-KHALIK: Now, given the potentially severe consequences of this, do you think a 95 percent confidence level associated with this calculation is appropriate?

MR. WOJCHOUSKI: I believe it is appropriate.

MEMBER ABDEL-KHALIK: Okay. That is a judgment. Okay. And so we'll move on.

In your analysis, have you done only the 59 calculations required to determine the 95/95 value or have you done more calculations?

MR. LI: That is right. We only did 59 calculations for this.

MEMBER ABDEL-KHALIK: So you have no idea where this graph would be if you were to assign a 99 percent confidence level, for example? How close would it get to the deterministic calculation?

MR. WOJCHOUSKI: We have not done those calculations.

MEMBER BANERJEE: So to explain to me when you go to those curves with the minimum and maximum, maybe you can go to one which shows the mean, the deterministic, all those nice colors. Okay. Take that.

So the 2 is your best estimate. Let me call it a best estimate because I understand what that means. I don't really understand these curves, but two is your best estimate.

MR. WOJCHOUSKI: That is what we expect.

MEMBER BANERJEE: Yes. And one is your best estimate plus uncertainty. That's what I would call it, with a 95/95, right? If I said 99, it would be higher?

MR. WOJCHOUSKI: A little bit higher.

MEMBER BANERJEE: Yes, all right. So 1 is best estimate plus uncertainty. And I see that that's not all that different from 4, I mean, within -- it's not gaining you all that much, at least in this curve. I mean, there could be other scenarios where it does.

What you would normally use as best estimate plus your uncertainty, that is going to be your determining -- that is what we do with other things, right, unless the staff has a deal with this other than best estimate, this uncertainty.

MR. LOBEL: When I give my presentation, I have some curves like this that I'll show again for conservative, realistic, and statistical. And the point that we have tried to concentrate on isn't so much the pressure and the temperature, but the thing we're really interested in is whether the pump is going to have what it needs.

And so what we are looking at in terms of statistics and conservative and all of that is the available NPSH and the margin from available to required NPSH. And I'll show you those curves. And that's what we're asking for in the guidance.

We're trying to get away from looking at containment conditions, although they feed into the available, and look at what the pump really needs. So we're going to look at the available NPSH and the required and the margin between those.

MEMBER BANERJEE: Right, but there will be a best estimate plus uncertainty there in your calculations, right? It depends on --

MR. LOBEL: Not quite that way, but yes, there will be an estimate of a realistic. And then there will be an estimate of a conservative and a statistical where we can quantify different levels of available NPSH.

MEMBER BANERJEE: So if I understand this curve -- maybe I don't know who wants to answer this, but one is really what would -- imagine this is what we were using as a measure at the moment, that we are trying to predict. Pool temperature here looks like maximum clad temperature, too.

MR. LOBEL: Okay.

MEMBER BANERJEE: So it's 1 that could be used, not the 2 ever, unless you have something to say about that.

MR. LI: Yes. Actually, the calculation, we did use 1.

MEMBER BANERJEE: Okay.

MR. LI: So that is a one-sided upper

limit for 95/95.

MEMBER BANERJEE: Okay.

MR. LI: Yes. We used 1 to calculate the curve in the slide 20.

MEMBER BANERJEE: Right.

MR. LI: Yes.

MEMBER BANERJEE: It's not 2 ever?

MR. LI: No.

MEMBER BANERJEE: No. And certainly not 3? All right. So that at least satisfies me that it's one that you have to use.

MR. LOBEL: Yes.

CHAIR SHACK: Although in some -- you know, this is not just uncertainty in a calculation. What we are really looking at here is a range of scenarios. I mean, you know, the 1 is sort of if the accident occurs at the worst conditions in the summertime with the hottest pool. Three is actually a realistic calculation if the break happens to occur in January sort of thing.

So best estimate in this sense, I look at it as it's kind of a proportion of scenarios that you're dealing with more than in a classic best estimate plus uncertainties kind of thing. I'm trying to look at a range of scenarios here.

MEMBER BANERJEE: And it's true because, I mean --

CHAIR SHACK: It's a fraction of the time.

MEMBER BANERJEE: It is not a true random --

CHAIR SHACK: Well, that comes back to this 95/95 and what does it mean.

MEMBER BANERJEE: Because, really, if you take that bad-day scenario and then you put your uncertainty on that, well, then that's a different ball game.

CHAIR SHACK: Part of this is that, too. I mean, you know, the uncertainty in the --

MEMBER BANERJEE: Fifty-nine.

CHAIR SHACK: Well, that comes back to what are statistics?

MEMBER BANERJEE: Yes.

CHAIR SHACK: I mean, we are mixing things here between a range of scenarios and uncertainties.

MR. LOBEL: That's right.

CHAIR SHACK: I mean, it's all lumped into one calculation here.

MEMBER BANERJEE: So you could argue take the worst day possible. Then put your ordered statistics on that and see what the uncertainty is.

DR. WALLIS: It is a very important point, really. Should Minnesota and Vermont would be allowed to trade off their very cold winters against a very occasional warm water in the summer?

It's a very important point because what is happening here is the statistical method throws it all in together, like the winters and the summers all mixed up; whereas, the worst status of the plant in the summer is different than what it is in the winter.

MEMBER BANERJEE: So, Bill, if you were doing it the way you are saying, you would do a best estimate for let's say --

CHAIR SHACK: No. That says I want 95/95 for every day of the year. The question is, do I want 95/95 for all of my scenarios? But, you know, coming back --

MEMBER BANERJEE: It's not so clear.

CHAIR SHACK: I am sampling here from the conditions. Then, of course, I am also sampling from uncertainties like the power in the reactor, which is a true uncertainty because in any given day of the year, that is a truly --

MEMBER BLEY: There is a correlation there, the hottest and coldest days. So there is a correlation there.

CHAIR SHACK: If you run this thing at full power, this is a nuke. I mean, if we want to run it at full power, the power for Minnesota Power probably goes up and down during the year. But I think the --

MEMBER BANERJEE: If you want to introduce the phases of the move into your DBA --

CHAIR SHACK: All I want to say is that this is slightly different from a best estimate plus uncertainty, that there is kind of a mix of things going on here.

MEMBER BANERJEE: Which is why I am having difficulty grappling with this methodology. I mean, it's not clean in the same way as you do it for a CSAU problem, where --

MEMBER BLEY: Or you are doing it for one scenario.

MEMBER BANERJEE: Or we can do it for different scenarios, but each scenario would have to have --

MEMBER BLEY: This is really a mix of scenarios. Bill has got that right.

MEMBER SIEBER: The problem is you have to do it for all scenarios, even the ones you --

MEMBER ABDEL-KHALIK: But wouldn't this

problem be alleviated if you have more realistic distributions from which you are sampling that are consistent with the time distribution of the various parameters, whether it's winter or summer?

MEMBER BLEY: I don't quite --

MEMBER ABDEL-KHALIK: I mean, we are mixing things, right?

CHAIR SHACK: It seems to me the uncertainty in the power -- you know, I am willing to believe that is kind of independent of whether it is summer or winter. So doing it --

MEMBER BLEY: Okay. Yes.

CHAIR SHACK: There may be some correlations in here between pressures and temperature. We didn't come up with the famous Dana Powers, you know, are all of these independent kind of parameters in the calculation. We could go through that, but just sort of looking at it in a rough engineering sense that I don't see that is the big problem here.

MEMBER BANERJEE: He's really saying the surface water temperature is the heat sink parameter which is correlated for the time of the year.

DR. WALLIS: If you did this calculation for every day of the year and then plotted it, those would wiggle up and down. Now we know it's July. Then you would have a different curve. You would know it's December.

MEMBER BANERJEE: The issue is whether they should do the ordered statistics on the hottest day of the year.

PARTICIPANT: Then you break down to the deterministic again.

PARTICIPANT: Sure, sure. That's where you are.

MEMBER ABDEL-KHALIK: So what distribution do you use in sampling these various different parameters; for example, the heat sink temperature?

MR. WOJCHOUSKI: What we did for sampling it, every four hours of every day for five years, we pulled all that data together, put it in an Excel spreadsheet, then went ahead and set up bins, basically temperature ranges, 32 to 35, 35 to 40, straight on up.

Then it had the Excel program go through and say, "Here is my data that I took off the process computer. Put an X wherever it meets that range," added those all up, calculated how many days that was.

Now I know how many days in each bin they are and then came up with an exceedance probability on them. So what you find out is between the 95 and -- excuse me -- between 85 and 90 degrees, there are 2 or 3 data points, period, very few data points between that range because we don't get that high.

Where you are sitting between the 32 and 35 degrees we'll have 6-7 hundred days over those 5 years worth of data. That hits those points. So that's how you come up with it.

MEMBER ARMIJO: What did you do with decay heat? Did you --

MR. WOJCHOUSKI: Decay heat --

MEMBER ARMIJO: -- pick a range or did you say, "I'm going to pick it at the end of cycle what I've got. You know, this event will happen at end of cycle" and make that part deterministic, even in your statistical?

MEMBER SIEBER: Which curve did you use?

MEMBER ARMIJO: Yes.

MR. LI: Okay. Actually, this one we answered this question to the NRC RAI. So, actually, this here is bounding. So we use end of cycle, consider the exposure, the enrichment, everything, and also he has the methodology that the 0636 considers other --

MEMBER ARMIJO: So in this analysis, even though it's statistical, you were deterministic about the decay heat. And you picked the most --

MEMBER SIEBER: An official curve.

MEMBER ARMIJO: -- severe situation.

MR. LI: It came in also a statistically --

MEMBER BANERJEE: It is sampled. The --

MEMBER ARMIJO: It is sampled again. So the event could happen at the beginning of cycle or could happen mid cycle or end of cycle, but wouldn't the worst case be end of cycle?

MR. LI: We didn't -- I am sorry. I interrupted you. Actually, we didn't do that. So the decay heat curve we used is the most conservative curve. So basically from that curve, you would get nominal value and one sigma, one sigma.

MEMBER ARMIJO: Right.

MR. LI: So we --

CHAIR SHACK: You got a bounding value for the decay heat, but he does an uncertainty on that so that --

MR. LI: That is right.

CHAIR SHACK: Because he really doesn't know what that cycle condition -- so he's got the worst point in the cycle. He's not bearing the scenario for the -- he is including an uncertainty in that variant.

MR. LI: That is exactly right.

MEMBER BANERJEE: That is consistent, I think, with the CSAU.

MEMBER ARMIJO: That's right.

CHAIR SHACK: As I say, that comes down to what you are really doing here, which is a mix of these things.

MEMBER BANERJEE: The concern that I have, though, on the day of the year when this LOCA occurs is really you're saying you're putting some probability on the chance of a LOCA occurring.

MEMBER ARMIJO: That's right.

MEMBER BANERJEE: And that to me is a curious way to do it, you know. That's why I'm saying the older statistics should be done on the hottest day of the year if you really want it.

MEMBER ARMIJO: At the end of cycle, end-of-cycle power, back to deterministic.

MEMBER BANERJEE: Well, it's not clear. You're really talking about the probability of a LOCA.

MEMBER ARMIJO: I agree.

CHAIR SHACK: Gentlemen, this is a Friday. So we can't run over schedule too much. If you have a burning question, please ask it. But otherwise I would like to bring this part of the session to a halt.

MEMBER BLEY: I just want to make sure I understand what I thought I heard earlier. Despite all the things that are mixed into this uncertainty calculation, when you get to the end and you show us curves, you're taking what would be equivalent to the number one curve in this particular calculation as what you're showing us?

MR. WOJCHOUSKI: That would be used to --

MEMBER BLEY: Have a comparison.

MR. WOJCHOUSKI: -- have a comparison into --

MEMBER BLEY: What's deterministic.

MR. WOJCHOUSKI: -- your NPSHa.

MEMBER BLEY: You're taking --

MEMBER BROWN: That is the statistical curve that's fallen into the lines there. That's the way I read that.

MEMBER BLEY: That is what I just wanted to make sure.

MEMBER SIEBER: I guess mine is not a question. It's a statement. I'll keep it to less than 60 seconds. Paragraph 5.4, "Defense in Depth," relies on NUREG-0800 or its basis for satisfaction, which is really a little bit different than the way defense in depth was originally defined. The idea was no dependence of one barrier upon another.

And the ACRS through the years initially had said "We aren't going to allow any dependence of one barrier on another." And they allowed a small and short, small amount for a short period of time. And as we move on and look at some of these applications, the small and short becomes a little bigger and a little longer.

And I would say that in these instances, beyond which a pump would be where you actually need containment pressure and ignoring those situations where a pump was cavitating but not destroying itself, that we have to be really careful about what it is we do.

And a probabilistic argument that says all of the barriers remain intact goes beyond the philosophy of the way the regulations in the Atomic Energy Act were originally written.

And so I intend to use caution in what it is that is proposed in the case of some BWRs. The allowances that are requested are modest and perhaps justified on these bases, but in other cases, they may not be.

So I urge a word of caution because of foundation, the founding principles of our agency, and the rules that are out there in the steps that the industry has taken and so that we just don't go over the edge.

Thank you.

DR. WALLIS: There was a question I asked at the beginning. You said you would get to it, this independence of barriers question.

MR. CROWTHERS: We'll get back to you. I don't know if we have had a chance to look at it. We'll look at it. We'll get back to you.

DR. WALLIS: You have got it now?

MR. CROWTHERS: I'm going to look at the Topical and see what we've got.

DR. WALLIS: Oh, I see.

MEMBER SIEBER: You are on page 39. It doesn't help very much to give a deterministic argument concerning the independence of the barriers in the answer to objective 2.

CHAIR SHACK: Crediting containment overpressure does introduce dependency between the first barrier, fuel clad, and the third barrier, containment.

MEMBER SIEBER: Yes.

CHAIR SHACK: However, previous examples indicate a very small delta CDF. So there is an insignificant increase in the likelihood of failure as compared to existing conditions.

MEMBER SIEBER: That is the probabilistic argument.

CHAIR SHACK: Okay. I would like to take a break for ten minutes. And if we can come back in ten minutes?

(Whereupon, the foregoing matter went off the record at 10:12 a.m. and went back on the record at 10:25 a.m.)

CHAIR SHACK: I would like to come back into session now.

Our next topic will be the NRC review of the licensing comparable report that we just heard about from the BWR Owner's Group. And Mr. Sallman from NRR will be presenting to us.

MR. SALLMAN: Good morning. My name is Ahsan Sallman. I'm a reactor systems engineer in the Containment and Ventilation Branch of NRR. And I'll go over the safety evaluation part of this topical report. Thank you.

The overview has been presented by the

Owner's Group. So we'll go through the highlights that staff looked at in order to provide the safety evaluation. The staff looked at these GDC-35, -38, the Standard Review Plan 6.2.2, Reg Guide 1.82, and 1.157 to perform the review.

In the technical review, we looked at the deterministic NPSH available analysis and the staff found that the topical report had conservative assumptions and bounding values of inputs. And the typical analysis that was done by the Owner's Group had been accepted by the staff in the previous containment overpressure reviews.

The topical report had a conservative computer code, SHEX, which has been accepted by NRC for previous licensing calculations.

CHAIR SHACK: Now do you really believe that SHEX itself are conservative? Or does all the conservatism come from the assumptions that you are making for the inputs?

MR. SALLMAN: Both, inputs are conservatives and the SHEX itself is a conservative code.

MEMBER ABDEL-KHALIK: And how was that determination made?

MR. SALLMAN: This is in the past, I

guess.

MR. LOBEL: How did the staff determine that?

MEMBER ABDEL-KHALIK: No. The question is that the code is conservative both because the models are conservative and the inputs are conservative. And the question then is absent a formal evaluation of SHEX, how did you arrive at the conclusion that the models within SHEX are conservative?

MR. LOBEL: Well, there was a presentation made to the staff many years ago. There were some view graphs that listed some of the conservative assumptions in SHEX. And we have done independent calculations ourselves for some of the power uprate submittals.

We did a comparison using MELCOR a while ago for the Duane Arnold power uprate. We did comparisons for the topical -- well, we did comparisons for the guidance document that we are going to put out that I'll show later.

So it is a combination of looking at the assumptions that were made and seeing that they appeared to be conservative. They were on the conservative side. And staff calculations comparing SHEX and GOTHIC and to MELCOR and CONTAIN.

So there have been two staff codes, MELCOR and CONTAIN, and the industry code that our branch is using now for containment calculations, GOTHIC, and all those show that SHEX itself is biased to the code.

So when we put in input from -- we put in the same input basically into our code that SHEX used, which the input has conservative assumptions in it, SHEX is still more conservative than those codes.

DR. WALLIS: I'm rather puzzled, Richard, I mean you've got two things you worry about. You worry about being conservative in the maximum containment pressure for a containment and you're really conservative in the minimum containment pressure.

MR. LOBEL: Right.

DR. WALLIS: And I don't see how the same code can be conservative in both directions.

MR. LOBEL: Well --

CHAIR SHACK: Smart code.

MR. SALLMAN: Well, the inputs are --

MR. LOBEL: Yes, go ahead.

MR. SALLMAN: -- the inputs to the -- first of all the inputs are conservative and inputs are biased --

DR. WALLIS: I understand the inputs can

be conservative because you can bias them one way or the other. But the code itself, how can it -- the way it models with nodes and so on, it is going to be biased up or down. But it can't be both biased up and down.

MR. LOBEL: GE can correct me if I'm wrong but it is biased in the sense that it increases the -- it overestimates the temperature. And that's the same for both.

And the assumptions do have a big effect. But the SHEX is biased to give a higher temperature. The higher temperature is the most important parameter for this --

DR. WALLIS: High temperature of what?

MR. LOBEL: I'm sorry, highest temperature of the suppressible water.

DR. WALLIS: But not of the containment atmosphere because that would change the pressure, right?

MR. LOBEL: Well, the containment atmosphere could be made higher. The containment atmosphere for the purposes of design basis calculations, the highest temperature for that you obtain with a small steam line break analysis.

When you do the peak pressure analysis,

you bias the assumptions to give you the peak pressure. When you do the suppression full temperature analysis, you bias the assumptions for that. But the code is also biased for that. I don't know, maybe GE wants to add.

MR. LI: Yes. I totally agree. So actually we have two kinds of calculations, one called containment integrity. Actually you want to maximize the pressure so basically based on the inputs.

So for this NPSH calculation, we want to minimize the pressure and maximize temperature. For both cases actually we maximize the pool temperature. Since that is a design limit, we have to --

DR. WALLIS: For things like heat transfers to structures, you assume in one case the maximum and in another cost the minimum it could be?

MR. LI: For the NPSH calculation, as I know, we credit that since we will heat transfer to the heat sink as we reduce the pressure for the integrity calculation. For some plants, we did credit for some and not. So in order to maximize pressure. So that's based on their licensing basis. So that will change.

DR. WALLIS: Then there are things like how you nodalize the containment.

MR. LI: We don't have nodalization. For the SHEX, it is a very simple code. RPV is one node. Drywall is one node. And the separation pool is one. And wetwall is one. So actually basically it is not an estimating code. It's a simplified code.

DR. WALLIS: So which way does that bias the results? Up or down?

MEMBER BANERJEE: Randomly more or less.

MR. LI: Not randomly. It actually depends on what is your purpose.

MR. LOBEL: You have to realize for the peak pressure calculation, the peak pressure occurs in a very, very short time. So the heat transfer usually doesn't have much of an effect on that. It's more the flow resistance through the vent system to the suppression pool that you make conservative. That keeps the pressure up higher for the peak pressure calculation.

MEMBER ABDEL-KHALIK: But what we're trying to find out is whether the bias up or down is determined by varying the input parameters only or there are specific model approximations or assumptions that you change depending on whether you want the code to bias the results high or low.

MR. LI: I think this --

MEMBER BANERJEE: Such as the condensation coefficient for the loss. I mean there are obviously --

MEMBER ABDEL-KHALIK: Yes. That's what we're trying to find out. What parameters do you bias within the model rather than the inputs that would cause the results to be either biased high or biased low?

MR. LI: Mainly through the inputs. So we do have another parameter. So we discussed it before. We call it mixtures coefficient. Actually you the break flow, depending on the condition in the containment, you will have some liquid flashing. It depends on the condition. You may -- if it's cold, there is no flashing.

We have another parameter actually controls. Since you have this flashing and heat through, you have some kind of a heat transfer between the break flow with every measurement. So that one for calculation, we really set it in the way with the sensitivity study actually response to the staff's RAI. So we set it in the conservative direction.

DR. WALLIS: Well, I understand all these inputs but I don't know how you can make the statement the code is conservative because --

CHAIR SHACK: Well, I think we've probably beat this enough. If we can just move on?

MR. LOBEL: I think maybe that is a question if we're going to have a proprietary session, maybe GE can speak to some of the assumptions in SHEX then.

MEMBER BANERJEE: It would be helpful if you just outlined SHEX during this closed session with the model parameters which contribute to model uncertainties. Can you do that briefly so that we understand where the model uncertainties arise here?

MR. LOBEL: Yes.

MEMBER BANERJEE: Thanks.

MR. SALLMAN: Okay. We will proceed. Statistical NPSH analysis uses order statistics method that is NRC approved. Reference 17 is the reference in the Owner's Group topical report. And it uses conservative values of some while some remaining input parameters are sampled.

It quantifies uncertainty in the output, which was Hww parameter, wetwall pressure minus the vapor pressure. The calculated NPSH is more conservative than a 95/95 because a lot of the inputs were used as conservative.

DR. WALLIS: Now this input parameter

sampling, you heard the discussion about

MR. SALLMAN: Yes.

DR. WALLIS: -- whether you can trade off Winter versus Summer because you don't when the LOCA is going to be. Is that okay with you to do that?

MR. SALLMAN: That's the statistical approach.

DR. WALLIS: Well, the statistical approach on the river temperature, river temperature in the winter is probably, you know, it's 30 or 40 degrees or something all winter.

MR. SALLMAN: That's right.

DR. WALLIS: And then for a few times in the summer, it goes way up. And so if you use statistics and say we're going to smooth that over the whole year and make a probability distribution, you are simply saying we don't know when the LOCA is going to be.

So it is fair to do that. Is that okay with you? Or should you look at the worst days in the summer and say we've got to be okay then? And then do statistics about that.

MR. SALLMAN: The worst days in the summer, so that would not be a representation for the entire year.

CHAIR SHACK: It comes back to this question whenever you guys call this calculation realistic and I don't think -- you know, it's realistic some days of the year. It's conservative some days of the year. And it's unconserve -- I think it's much fairer to say that you've got a typical result.

Fifty percent of the time it could be a little more. Or fifty percent of the time it could be a little less. You know when we mix this uncertainty with the different scenarios, we get a kind of confusing state of things.

MR. LOBEL: Yes, you are right. They are broad descriptions. They're not -- it isn't exactly -- the statistical calculation isn't all statistical, the realistic calculation isn't all realistic. It's must more so than conservative.

DR. WALLIS: But the question is is it okay to tradeoff the cold days in the winter with the hot days in the summer? Or should you make a separate evaluation of the summer without letting the winter balance it?

MR. LOBEL: In our calculations, we assume the hot temperature for the statistical calculation. Is that right?

MR. SALLMAN: We assume the maximum -- we sampled -- we did a calculation similar to the Owner's Group calculation in 59 runs. And we sampled between the two extremes, random sampling.

DR. WALLIS: Between some summer and winter? Between 90 degrees in the summer and 38 degrees in the winter?

MR. SALLMAN: Yes, yes.

DR. WALLIS: Random sampling?

MEMBER BROWN: So you didn't use the hottest temperature then?

MR. LOBEL: No, I was wrong.

DR. WALLIS: You didn't use the hottest temperature. And you used an actual distribution based on measurements throughout the year?

MR. LOBEL: We --

MR. SALLMAN: Sorry, we just randomly -- we did not use that sample.

DR. WALLIS: You can't be random unless you know the distribution.

MR. DENNIG: Bob Dennig --

MR. LOBEL: That we got from --

MR. DENNIG: Rich?

MR. LOBEL: Yes?

MR. DENNIG: We could certainly break up

and we did talk about doing a separate calculation for winter and a separate calculation for summer. The temperature distribution, you know, it weights the probability of the thing being that bad when the LOCA happens.

And the question is is that satisfactory in the big scheme of things? And I think we can think about that. I mean we understand your point.

But we take that into account with the conservatisms that we put in and some other conservatisms for scenario, for example, for the single failure assumption, and some of these other things that we'll talk about, perhaps about SHEX. But we understand the point of your question.

MEMBER BANERJEE: Also, the main sensitivity, I take it, is to the river temperature. Or is it not? The sensitivity is primarily due to that. Or are there other factors which are as important?

MR. LOBEL: There is a sensitivity table in my presentation later that assigned -- ranked all these variables in decreasing order of sensitivity. And so you can look at that and see where it ranked. And it ranked high. I think power was first.

MEMBER BANERJEE: Okay. Power we have no

disputes over.

MR. LOBEL: Yes.

MEMBER BANERJEE: That is fine.

MR. LOBEL: But it was definitely one of the most sensitive.

MEMBER BANERJEE: Other than power, is this the most sensitive to surface water?

MEMBER ARMIJO: Stored energy, I would think that would be in the cycle.

MR. LOBEL: But we didn't have anything called stored energy per se.

MEMBER ARMIJO: Yes, but it's in the --

CHAIR SHACK: Yes, in the BWR Owner's Group, it is the biggest parameter mostly because it has the widest range, I think, as much as anything else. I mean it gives them a ten-degree variability.

DR. WALLIS: I think it would help me if rather than just talking about it, we had an actual statement showing what you did. What you used for a probability distribution for river temperature and where it came from and why it was okay to average throughout -- to use the sort of the statistic for the year rather than focusing on summer, which is the worst time.

MR. LOBEL: Well, we can tell you what we did.

DR. WALLIS: But that doesn't --

CHAIR SHACK: That's all we can do today.

MR. LOBEL: I guess we haven't been very clear about that. We can tell you what we did. Why we did it, let me say one other thing. Maybe this is just philosophy, but the topical report, the deterministic analysis is still going to be the licensing basis.

The topical report was done originally for that but the BWR Risk Group changed their minds. They didn't want to use it for a licensing basis. So it's only going to be used to demonstrate margin.

So looking at it that way, if we realize how they did things, then that gives us a perspective for judging the margin. And that's all we were trying to do. We weren't trying to say a particular thing was acceptable or not acceptable as much as just trying to understand so we could understand what the margin.

CHAIR SHACK: But you have the same problem whenever you give a realistic calculation because that's -- you have to tell me what the realistic calculation really is.

MR. LOBEL: Well, tell me if I'm wrong

again. I think I got things mixed -- it's the realistic calculation where we still use --

CHAIR SHACK: Okay, it uses the summer day.

MR. LOBEL: -- the summer day.

MR. SALLMAN: The realistic calculation uses the maximum summer temperatures --

CHAIR SHACK: Okay.

MR. SALLMAN: -- which is 90 degrees. The tech spec uses 100 percent power, zero sigma decay heat, and the travel pressures are nominal values which is higher than the minimum. The relative humidity is about -- not about -- I think we used 40 percent instead of 100 percent. So those are the kind of realistic numbers that were used in NRC's calculations.

CHAIR SHACK: So you take a bounding scenario but you use realistic input for that bounding scenario --

MR. LOBEL: Yes.

CHAIR SHACK: -- as just sort of a way to look at it.

MR. LOBEL: Yes. Because we're still -- we're calling it realistic but it is still taking a single failure assumption also. So it is realistic in the input but the scenario is still pretty much the same scenario.

MEMBER BANERJEE: But do you then do some statistics on that?

MR. LOBEL: No, not on that -- on the realistic?

MEMBER BANERJEE: Yes.

MR. LOBEL: No, no.

MEMBER BANERJEE: So that's just the bounding scenario?

MR. LOBEL: The scenario is the same scenario. It's a large break LOCA.

MEMBER BANERJEE: Right.

CHAIR SHACK: On the worst day.

MR. LOBEL: And we do the same calculation but we use input that is more what you would expect rather than bounding --

MEMBER BANERJEE: Okay.

MR. LOBEL: -- input. And it's not statistical. We don't do any statistics with the realistic calculation.

MEMBER BANERJEE: Realistic inputs for the worst day? That's what you're saying?

MR. LOBEL: We used -- because of this business of trying to figure out what to use for a single calculation when the temperature can go from 30 to 80 degrees, we decided to just use the 80 degrees.

MEMBER BANERJEE: Okay.

MR. LOBEL: In our calculations.

MEMBER BANERJEE: Yes.

MEMBER RAY: I don't want to -- this is such a fascinating discussion, I don't want to divert it. But if we have time, I'd like to come back to Rich said about what the purpose of the topical report is because we got mired down in river temperatures and stuff as if we were just applying this to one plane.

And I think the fact is that the topical report plays a different role. And I'd like to understand that better. But I don't want to -- like I said, this is too fascinating now.

CHAIR SHACK: Well, I'd like to move on.

MEMBER BROWN: Can I interject since I'm not a -- I just want to provide another perspective of the way I come from it. Bill knows how I think about this from my past background in the naval nuclear program.

But I'm trying to relate this -- the statistical approach in this case, and I'm not trying to say we never used that because we did. You have to in some cases.

But so the way we do sizing of cables, for instance, in ship, you look at a ship. Typically today you will have connected load of somewhere -- look at an aircraft carrier, probably 100 megawatts of connected load. And you have about 30 or 32 megawatts of your generating capacity.

So as you size and layout your circuits, you determine, based on load demand factors, how may of those are going to be on this but it is random. It is a truly random thing. This compressor will be on, this one will go off, this one will come on. And it is balanced all throughout the ship.

So in a random manner like that, we have, for instance, and the same thing goes on in your house, you'll look at -- you've got a 20-amp circuit for all your circuits. But if you put -- and that's based on a statistical evaluation in some way in the electrical world that you are not going to hook up 20 amps from one outlet when you have a bunch of other things on it.

And if you don't, your wife puts the iron on at the same time you've got the toaster, the breaker trips. But those are random type of events.

Here, to me, the way that I've been looking at this is that you are not truly random in establishing how the parameters are set up. I mean you've got periods of time during the year when certain parameters are fixed. They're there.

And if I relate that to the circumstances I faced in the electric plant world, we had circumstances were you have this big line with a bunch of stuff on it, there would be a pump. It was there all the time. You couldn't put a load -- it had to be one. It had to be figured at the highest temperature advice, I'm using that as an analogy.

So what I've been trying to figure out is there a way for me to change my mind into how I think about this from the deterministic standpoint to say are there random parameters where this, you know, combining them over the entire year and everything could kind of make some sense because they are never the same thing in the same place.

Where there are periods when you have fixed number, and they're going to be there for one month, two months, three months, in which your risk is far higher. And so I'm just listening to the conversation and integrate then -- and I don't see a concise -- I mean Graham has addressed in terms of, you know, when do you pick this. And that's the way I've been looking at it.

And if I could see something that kind of put that in that category, what are the random ones? Which are the ones -- we really ought to pick the highest and then do the analysis. That would seem to me to be a more acceptable approach. I don't know whether I was totally confusing but that's kind of the way that I --

MR. LOBEL: The licensing basis analysis is that. We pick the highest temperature. The deterministic analysis that is used as the licensing basis we pick the highest temperature.

MEMBER BROWN: How about the heat sink temperature in this case?

MR. LOBEL: The service water, yes, the ultimate heat sink temperature, there are calculations that show that the high temperature is more conservative than the low temperature. The low temperature lowers the containment pressure because the sprays are spraying cooler water.

But the high temperature is more conservative because temperature has a bigger effect than pressure does. But for the deterministic analysis, all of these are biased to give you the worst result. The highest temperature is used, the end-of-cycle decay heat --

MEMBER BROWN: But in our program we had to do this in similar circumstances. And on this type of stuff, we went and looked at the range of the eight or nine parameters and said okay, here are -- six of those nine are going to be bouncing all over the place and three aren't.

So we always pick those three to be the worst. And then we did the statistics based on the other ones because they weren't -- they couldn't occur in some circumstances under the same time.

And I haven't heard that in terms of laying out against each of the parameters that is being considered in the analysis. And maybe I'm not smart enough to figure that out from reading it.

MR. LOBEL: We don't do that for the conservative analysis. Everything --

MEMBER BROWN: Oh, I understand.

MR. LOBEL: -- gets a bias.

MEMBER BROWN: I understand that.

MR. LOBEL: Okay.

MEMBER BROWN: But if you want to -- you are trying to back away from that using a statistical method.

MR. LOBEL: Yes.

MEMBER BROWN: And I'm just trying to

integrate it -- you know, understand from my standpoint of, you know, can you truly take ten parameters and move them all down so that, you know, they are in this variable range where you can assume they are all random when they're not.

CHAIR SHACK: I think we ought to let them move ahead because we're going to come back to the pump program where, again, what's conservative and what's not conservative becomes unclear as to --

MEMBER BROWN: That's fine. I'm finished. I just wanted to give a perspective, that's all.

MR. SALLMAN: Okay. The next slide just discusses a few limitations and conditions for this. Some portion of the NPSHa analysis to be reviewed on a plant-specific basis like the head loss. And that's an example.

There is a new staff guidance, which Rich Lobel will present next. It requires margin for uncertainty in the required NPSH.

Model, and this is another condition, is model other than SHEX should be capable of analyzing LOCA and the special events.

Use of best-estimate code shall include uncertainty to calculation in the statistical method.

The topics that were not reviewed by the staff, one of them is a risk assessment --

DR. WALLIS: I don't understand the purpose of that bullet.

MEMBER ARMIJO: I don't either.

DR. WALLIS: I mean the whole purpose of statistical method is to use uncertainties. So what do you mean by calculation uncertainties. Is that something different from the uncertainty that is already in the statistical method?

MR. SALLMAN: It is the difference between the conservative code and the best estimate code if they use -- some licensee uses a best estimate code, we are saying that an uncertainty in the calculation will be used -- will be added.

DR. WALLIS: So this is uncertainty that is due to the code itself --

MR. SALLMAN: Yes.

DR. WALLIS: -- such as the way you nodalized --

MR. LOBEL: That's what we are saying. For the topical report, SHEX was used. SHEX is a biased code. So there wasn't any -- there was a preliminary discussion of model uncertainty and we dropped it.

If somebody comes in with another code

that is a best estimate code, then we would ask for a model uncertainty analysis.

MR. SALLMAN: Okay. Topics in the report were not reviewed by the staff, one of them is the risk assessment, which will follow the SPR 19.2 Appendix D.

Accident management to preserve COP and modifications that would reduce or eliminate need for COP. That is our Appendix C and D of the topical report, which are to be reviewed on a plant-specific basis.

We'll just go over a few RAIs. There were like about 30, 36 RAIs. But we'll just go over about four or five of them.

First RAI was how is the statistical approach consistent with and different from the NUREG/CF-5249, which is Quantifying Reactor Safety Margins. And I think that response was discussed in the earlier presentation.

The next one is will the same computer code, SHEX, be used as in the topical report? If not, what should be the conditions for using a different code? And the response was not limited to SHEX. Aspects of topical report specific to SHEX should be evaluated and dispositioned by the licensee if a different containment response model is used.

RAI-7, for some BWRs in which MSIV leakage is considered separately from containment leakage, how is this considered in the analysis?

Response was maximum allowed MSIV leakage should be combined with the maximum containment leakage rate for input as a conservative leakage assumption.

The next RAI-10, what type of statistical distribution will be used for variables included in the statistical analysis? Will this be determined on a plant-specific basis? What guidance or criteria, if any, are used to determine the statistical distribution?

Response was normal distribution or with a distribution that represents plant/parameter-specific data, for example, normal distribution for power and decay heat, and parameter-specific for those that can be measured periodically.

RAI-16, why is it conservative to assume that spray droplets are in thermal equilibrium with airspace before falling to the bottom of the drywell or suppression pool?

The response was spray water being less than the drywell or wetwell temperature, the containment pressure would be minimized due to the energy transfer from the airspace to the spray liquid drops.

RAI-19, how is a credit for operator action of throttling of flow included in the analysis for special events?

The response, timing for the special events would be dictated by the analysis results and consistent with operator actions as directed by procedures.

RAI-34, Section 2.3 of the report states that if COP is required, the most realistic NPSHr should be used. Explain what is meant by realistic NPSHr.

Most realistic, the standard three percent required NPSH curve, but the most realistic term was used to allow licensees the option to contact pump vendors to establish NPSHr values commensurate with the minimum acceptable hydraulic performance.

DR. WALLIS: What I haven't heard yet really is what is the criterion for acceptability? Is it that they never go beyond the standard three percent curve? Or are they allowed to do it for a certain period of time? And for how long are they allowed to use COP credit? Is there a time limit on for how long? I don't know what the evaluation criteria are. And are we going to get to that?

CHAIR SHACK: Well, I think that will come in the guidance, something that Rich is going to talk about.

MR. LOBEL: Yes, we can talk about that.

DR. WALLIS: That's good because I haven't heard about it yet. And I just want to make sure. Can we sort of step over this for a little while or something?

MR. SALLMAN: Our discussion of the acceptability of required NPSH values used should be included in the individual license amendment request if based on other than three percent or one percent head drop values. And the BWR Owner's Group concurs with that.

And the next slide, NRC performed a similar NPSH analysis to support the guidance document that will be presented next. And the staff analysis will discuss the guidance document presentation.

Conclusions, a deterministic analysis shall be the licensing basis. Statistical analysis is to be used to quantify uncertainty and demonstrate margins.

DR. WALLIS: Well, I don't quite

understand that. I mean it's so simple. If they've already got a license and the deterministic analysis is satisfactory, why do they need to do anything else?

MR. SALLMAN: To demonstrate margins.

DR. WALLIS: Well, why do you need to do that if they've already got a license and it is satisfactory?

MR. LOBEL: Well, I think it's partly to help the Committee --

CHAIR SHACK: It's ACRS.

(Laughter.)

MR. LOBEL: The original suggestion was that from the experience with Vermont Yankee, we talked with General Electric Hitachi and the BWR Owner's Group about isn't there some way we can reduce the conservatism that -- you know, it sounded like terrible things were happening when really it was that the analysis was so conservative.

Wasn't there some way that we could get together and agree on an analysis that was less conservative that was still satisfactory to both sides. And so the statistical approach was suggested and started. And as that was going along, we had a call with the Owner's Group and they said for their reasons, that they didn't want it to be a licensing basis. So it became just a --

DR. WALLIS: Well, to go back to VY, VY didn't meet the requirements on the basis of a deterministic analysis.

MR. LOBEL: Well, they met it with containment pressure and such.

DR. WALLIS: Well not for a long time.

MR. LOBEL: Oh, the short time and all that, they did -- VY did use containment pressure. And they showed that -- and this isn't true for all BWRs -- but they showed that if they just made some other more realistic assumptions, just a few of them, they didn't need overpressure.

DR. WALLIS: Well, I think the ACRS was concerned about how much pressure they needed and for how long they needed it.

CHAIR SHACK: Well, our last letter said they should do the deterministic analysis and that should be the licensing basis. And they should do this analysis to give us some idea of the margins.

So we asked for this. We got it. Now we can't really complain about it.

MR. LOBEL: And I think the guidance is also going to -- that we're going to talk about, what we're proposing for the future is going to demonstrate margin, too, in a different way.

MEMBER BROWN: For perspective on margin, no matter what accident or transient you're dealing with when you do it on a design basis and you meet your criteria, whether it's 1.1, DNB, whatever the ratios are, you really want to know what a realistic -- and you don't want people thinking they're walking on eggshells when they're operating a plant.

There was a real problem years ago with people operating plants. And this going back 20, 25 years before most of you were born but -- that's a joke --

(Laughter.)

MEMBER BROWN: -- where we did have operators that thought that they were operating at the edge. They were very nervous about things -- you're not getting this right or that right. And having an analysis, it showed there was, you know, it was a very conservative approach to doing things.

So I just throw that out. I think whatever the Committee previously agreed, that's a great idea to have an idea that hey, look, we're not operating on the -- you know, right at the edge of all of this stuff, the very conservative line.

MR. LOBEL: And that was the problem with the Vermont Yankee power uprate that we almost went to a hearing because of the conservative results in the calculation. I think it was a lot to do with that. Some of it was just people just didn't want the power uprate.

But some of it was -- one of the concerns for that was the conservative analysis and it is hard for people, especially in the public, to understand this issue and the power rates.

MEMBER BROWN: They're not going to.

MR. LOBEL: And so that's one of the reasons we -- that's the main reason we approached General Electric Hitachi in the Owner's Group was to see if there was something we could do to make things a little --

DR. WALLIS: Did I misunderstand this morning though? I thought that you do the deterministic analysis and if it doesn't work then they do a statistic analysis. And then they submit that to show that the plant is okay. I thought there were --

MR. LOBEL: No, the deterministic analysis has to work.

DR. WALLIS: It has to work.

MR. LOBEL: That's their license --

DR. WALLIS: So there's no incentive to do this --

MR. LOBEL: The only thing is that they first do it without -- the topical report says you can first do it without -- with atmospheric pressure. And if that doesn't work, then you use overpressure. And if you use overpressure, then you do the statistical analysis to show you have some margin -- to show what the margin is.

DR. WALLIS: I know but if your deterministic analysis doesn't work --

MEMBER ABDEL-KHALIK: You have to define what work.

DR. WALLIS: Well, if the statistical analysis -- deterministic analysis shows that when you make these conservative assumptions, you don't have enough overpressure.

MR. LOBEL: Yes.

DR. WALLIS: The pumps with --

MR. LOBEL: That's what it means not to work.

DR. WALLIS: Well, I understood you did then was you then did the statistical analysis. You submit that to the NRC and say we don't need to base everything on deterministic analysis because our 95/95 shows we're okay. Isn't that what they do?

MR. LOBEL: No, it's just for margin. It's just to demonstrate margin. If they don't meet the deterministic calculation, that's their licensing basis.

DR. WALLIS: There's no incentive to do it.

MR. LOBEL: They haven't satisfied their licensing basis.

DR. WALLIS: So maybe --

CHAIR SHACK: The incentive is to satisfy the ACRS and the staff.

DR. WALLIS: I misunderstood what they said then.

MEMBER ABDEL-KHALIK: But the word work means that you can meet this condition that is required NPSH or the available NPSH is equal to the required even if you were to take full credit for all containment pressure. That's what the word work means.

MR. LOBEL: Yes. And what we're proposing is that there will be an uncertainty in available and then uncertainty in required that addresses the things that you are not sure of.

MR. SALLMAN: Statistically determined

NPSHa is, we say it's not strictly statistical because some of the import parameters are conservative that we already discussed. Then in staff calculation, we found that there was a similar trend in Hww and the temperature of the suppression pool with the Owner's Group deterministic and statistical analysis.

And the staff analysis will be discussed in the next presentation.

CHAIR SHACK: Any more questions for Mr. Sallman?

MEMBER RAY: Well, again, I have this -- we touched on it here just at the end. What is the purpose of the topical report? What role does it play? How is it used in the regulatory process? It is not Monticello-specific by definition.

For the sake of time, we should go on. But I'd like to again note that I would like to discuss that further if we have time because this is a -- I'm interested in what the implications are of that because as they said, the licensing basis remains deterministic and you satisfy it with overpressure. If it's too long or too much, you do the statistical analysis to show that you --

MEMBER ABDEL-KHALIK: No, we don't care about how long or how much as long as --

MEMBER RAY: You have to do the statistical analysis in accordance with the topical report if you are taking credit for containment accident pressure to show that it has got --

CHAIR SHACK: Understand the margin associated with that calculation.

MEMBER RAY: Right. Now presumably that calculation could say no, you don't have enough margin in theory. Or is that not even a theoretical possibility?

MR. LOBEL: The deterministic calculation?

MEMBER RAY: No, the second step --

MR. LOBEL: The statistical?

MEMBER RAY: -- that you take to show --

MR. LOBEL: Sure, I guess it could show that.

MEMBER RAY: And maybe in some theoretical way you could fail the statistical analysis also. That's what I'm trying to say.

But where else are we going to wind up doing this, you know? It seem like a new regulatory device to me that I'd like to understand how it works because I don't see why you can't apply it to lots of things that you don't satisfy.

Why not just come back in and do a

statistical report to say well, yes, I didn't satisfy the deterministic rule. But I got a lot of margin. So that's okay.

CHAIR SHACK: You have to satisfy the deterministic rule.

MEMBER RAY: All right, Bill. Make me say it the whole way. You satisfy the deterministic rule by taking credit for containment overpressure. But you can only do that to the extent that the statistical analysis says you have enough margin. Is that a fair rendition?

MR. LOBEL: No, it's only to demonstrate margin. It's only to show you that --

MEMBER RAY: Yes, to demonstrate something implies that you might not be able to demonstrate it to me anyway, okay, that's why I say it the way I do.

MR. LOBEL: I guess it is hard to see that if you met the deterministic you wouldn't meet the statistical --

MEMBER RAY: You meet the deterministic by taking credit for containment overpressure. So far so good?

MR. LOBEL: Yes.

MEMBER RAY: But if that happens, you have to do the statistical analysis to demonstrate margin.

And I thought that you just agreed with me that at least theoretically you might not pass that. That's all I was trying to say.

Now my conclusion is is that that's a new regulatory process. Maybe it has been used somewhere else. I don't know. But to me it's new.

CHAIR SHACK: It's probably new.

DR. WALLIS: Well, then, the LOCA they can used realistic analysis with uncertainty and the statistical method is the way of satisfying the regulation.

MR. LOBEL: Yes, so that's different.

MEMBER RAY: Again, I don't want to take up time here with this discussion that I'm trying to have here. And it seems I have a hard time stating it in a satisfactory way.

But in any event, I still want to leave that on the table because I'm concerned that this is a new --

CHAIR SHACK: Well, this is what we asked for.

MEMBER RAY: It may well be, Bill, but it is still new as far as I'm concerned. And I would like to have a chance to revisit that.

DR. WALLIS: I thought what we asked for

was the statistical analysis as the basis for how to satisfy the regulation.

CHAIR SHACK: No.

DR. WALLIS: We didn't ask for that?

CHAIR SHACK: No, we didn't ask for that.

MEMBER BLEY: Read the letter. Not in the letter.

CHAIR SHACK: Not in the letter. There were many discussions. But we didn't put that in the letter.

MEMBER RAY: I agree with all of that. I still think, though, that we're at a point where there is a new process on the table. And we ought to understand it and see if there are any implications that we're concerned with.

MEMBER BROWN: One of the other points that falls from that is if somebody has problems in some other area other than this, they'll say well, gee, you agreed to this approach because we've got a compensating factor in this other area, so let's -- so that's, I think, a little bit of that is the slippery slope routine.

MEMBER RAY: Yes, we are using margin here that we are deriving by this topical report for a purpose and I just think it can be used in many ways.

And I think we ought to understand it.

CHAIR SHACK: Okay. I think we're ready to move on now to the next topic.

Bill, are you going to make some introductory remarks?

MR. RULAND: Thank you, Mr. Chairman.

Good morning. As some of you -- well, most of you are fully aware, by letter dated March 18, 2009, the ACRS made five recommendations to the staff on the use of containment accident pressure for demonstrating the ECCS pumps can perform their safety function.

One of the things said was essentially, you know, it should only granted a little bit of pressure for a short time. Both the staff and the ACRS struggled with that. What does that mean? You know we know it when we see it. This is something that the staff has a tough time implementing as a practical matter.

So what the staff asked, well, how can these pumps fail? What is, in fact, the pressure is available? And ultimately what are the margins in both of those parameters?

So during the past year, the staff has developed a different approach than previously discussed with the ACRS. This new approach is described in the current draft guidance document that you have been provided.

Examples of the application of this guidance will be discussed today and have been discussed with the BWR Owner's Group and we got some information from them although for us to go forward explicitly for a particular review, the staff is going to need a significant amount of information from the particular licensee.

This guidance document, as I said, has been issued draft not only to the BWR Owner's Group but also to the PWR Owner's Group.

The staff guidance, as I said, focuses on pump performance. With the help of two experts in pump cavitation and pump NPSH, we have studied the phenomena that effect pump performance in these areas. We have also quantified the uncertainty in pump NPSH. The guidelines, we believe, are quantitative and the uncertainty in the margins have, in fact, been quantified.

The staff has also analyzed the risk of using containment accident pressure and will discuss those results with you today.

We are here today, of course, to brief you on this proposed guidance and to carefully consider your comments. Of course this is a Subcommittee meeting and you folks don't provide us letters as the result of Subcommittee meeting but the staff goal ultimately is to get a letter from the full Committee when we do that briefing.

Our discussions with the industry have just begun. And after considering the ACRS and industry comments, we intend to publish the interim guidance document. The final document will be a revision to the Regulatory Guide 1.82 and its current revision is Revision 3.

Those are my introductory remarks, Mr. Chairman.

CHAIR SHACK: Thank you.

Marty is next.

MR. RULAND: Marty Stutzke was kind of kidding about this presentation. He said this is one of the first time that the risk guy doesn't go last. And the reason we have asked Marty to go first is because we're trying to put the overall risk of this issue that faces both of us in its overall perspective. And then we will discuss the individuals parameters that I have mentioned.

MR. STUTZKE: You know, if things didn't

fail, I'd be out of a job. Okay, I'm Marty Stutzke. I'm the senior technical advisor for PRA Technologies. I would in the Division of Risk Analysis in the Office of Nuclear Regulatory Research.

My involvement with containment pressure for determining adequate NPSH started back with the Vermont Yankee EPU. At that time, I worked in NRR.

It continued on with the submitted Browns Ferry EPU. By that time I was smart enough or lucky enough to get transferred to the Office of New Reactors.

Then I got promoted and I moved to Research and I didn't hear anything about the subject for a year. And it was great. Unfortunately, Mr. Lobel happened to be in my office up on Church Street and he ran into Dr. Brian Sheron, who said of course Marty would like to help you out. So here I am.

Before we start the actual risk evaluation, what we've done is to conduct our own in-house PRA. What we've had before are licensee's evaluation of the risk like that. And it has been a little bit unsatisfying because I have to poke and prod the model through an RAI process.

So we built our own PRA-type of model. And that's the bulk of my presentation. There is a novel use of an old technique in there.

But before we get into that, I thought we would talk a few words about defense in depth since Dr. Wallis raised it almost immediately. And it's true. The impact on defense in depth of the use of containment pressure to determine available NPSH is one of the central issues here like this.

We tend to think about it thus far in what I'll call an elementary view of defense in depth, the old physical barrier concept. It's here's the clad, here's the reactor coolant system, here's the containment, like this.

The Commission's white paper actually provided us a definition of defense in depth and I've showed you some excerpts out of it. And you don't see the barrier concept leaping out at you. Rather it is a more holistic concept. Anything that we can do to improve the situation could be counted as defense in depth.

The last thing I would call your attention to is this notion of adequacy of or necessity of defense in depth should reflect risk insights. Okay. I won't call it a new concept. This is the first time the Commission actually annunciated it like this.

Shortly after the Commission wrote this

white paper, you guys issued a letter on the role of defense in depth in risk-informed regulatory systems. This is the rather famous letter that hypothesized the structuralist school of thought and the rationalist school of thought on defense in depth like this.

And, you know, the Committee's concern at the time the letter was written was maybe appeals to defense in depth had been used to making changes that seemed appropriate based on PRA-type of results. The phrase sticks in my mind, arbitrary, because that's in the eye of the beholder, right? But it is a rather catchy phrase that I continue to remember.

CHAIR SHACK: Seemingly arbitrary.

MR. STUTZKE: Yes. And then later on it's this idea unless you can justify defense in depth in terms of necessity and sufficiency, you know, you can't go forward with risk-informed regulation.

So the way that we tend to view this is there is some approach or some circumstances where it is reasonable to accept some reduction in defense in depth if the corresponding risk increase is acceptably small. It's not an either/or sort of thing. There is some sort of balance, a tradeoff involved like that. The problem is making that tradeoff to any specific situation like this.

And what we have to guide us here currently is Reg Guide 1.174. These are the acceptance guidelines consistent with defense in depth for seven bullets down like this. And the one that inevitably causes us the problem with respect to containment pressure credits is the independence of barriers. It's number five on the list because it's true. If we rely on containment accident pressure to provide NPSH and the containment loses its integrity, we could find ourselves in a core damage accident and damage to clad.

Okay, so we have just the very fact that we want to credit overpressure or containment accident pressure or whatever we're calling it today, induces that dependency in there. And that dependency doesn't matter on whether we're talking about 95/95 bounds or anything. It just simply exists. It is a matter of fact, okay?

So it is troublesome. Now there are situations where we achieve balances between defense in depth and risk before. I was asked earlier this week to gin up a list and we know when reactors were originally built and designed --

MEMBER BROWN: Hold on a minute, Marty. The last five pages -- it's the last five pages in your handout. We're on page four of the last seven pages.

MEMBER BANERJEE: Yes, somehow they are out of order.

MR. STUTZKE: Oh.

MEMBER ARMIJO: We're all catching up.

MEMBER SIEBER: Thank you.

MR. STUTZKE: Yes, I think these things got sent over to you late yesterday afternoon. It's been confusing.

MEMBER BROWN: Kind of like COP.

MR. STUTZKE: Yes, COP, CAP.

MEMBER BANERJEE: Are we at conclusions?

CHAIR SHACK: We're at similar situations.

MR. STUTZKE: Yes. But similar situations where we've achieved a balance between defense in depth concerns and acceptable risk are in the original design of plants. In other words, we accept plants that have possibilities of suffering interfacing system LOCAs, steam generator tube ruptures. These, in fact, directly bypass the containment.

We allow situations where redundancy or diversity could be lost. Whenever equipment is taken out of service for maintenance, there is some reduction in the defense in depth posture of the plant. And that is managed or limited by the allowed outage times that are provided in technical specifications.

We have a process, Reg Guide 1.177, that says how much increase in risk we can tolerate, the increase in allowed outage time we can tolerate. These are kind of interesting with respect to the containment accident pressure credit.

When we talk about a tech spec change to an allowed outage time, what you really see in risk space is a series of pulses. The risk is very small. The equipment is taken out. And the risk goes screaming up, okay, for the duration of that maintenance. Things are put back in proper order and the risk goes way down. And so you see spikes.

Now industry has a speed limit on how big a spike can be. But the staff has not formally endorsed that. We haven't accepted it or rejected it. Rather we base our judgment on the area under that risk pulse.

Containment accident pressure is a different type of animal than this. There is no spike. We're just talking about a bump up in the baseline risk and it is uniform throughout the year.

DR. WALLIS: No, it's not. It's worse in

the summer on the hottest days.

MR. STUTZKE: It can be worse in the summer and whatever but I'll show you how I tried to get rid of that, like that. And then finally there are risk informed changes that actually relax programmatic elements of defense in depth, risk-informed and in-service inspection, 50.69 special treatment requirements.

So what I'm trying to leave you with is the message that yes, we have, in fact, and we routinely strike balances between defense in depth and risk, like that. And so containment accident pressure should be treated the same way.

MEMBER BROWN: Go back one.

MEMBER RAY: Hold on a minute. That last statement is too -- go ahead, Charlie.

MEMBER BROWN: You said that we -- I looked at these three at the top, the interfacing system LOCAs, steam generator tube ruptures where we violate, I guess, the containment issue. In a PWR, if you have a steam generator tube rupture, do you violate the containment?

MR. STUTZKE: Yes. It will bypass the containment. You bet.

MEMBER BROWN: That's if it breaks -- you are talking about the stop value that's outside versus a stop valve that is inside?

MR. STUTZKE: It will go through the safety valves. Tube ruptures.

MEMBER BROWN: No, I understand that. But you can isolate it.

MEMBER BLEY: Not safety valves.

MR. STUTZKE: Not safety valves, no.

MEMBER BROWN: The steam generator stop valves?

MR. STUTZKE: You mean the overpressure relief valves?

MEMBER BROWN: Yes.

MR. STUTZKE: No, the code safety valves.

MEMBER BONACA: The direct way you effect defense in depth in this particular case is by changing the criteria for running the pumps. Essentially what you are doing, you're increasing the likelihood of cavitation of the pumps.

MR. STUTZKE: I understand.

MEMBER BONACA: Okay. So I'm trying to understand how that fits into Reg Guide 1.174. You know you listed a number of attributes. And maybe they could be defense against potential common cause failures.

MR. STUTZKE: Yes, in order to really get after it, one would have to --

MR. RULAND: Marty, could you repeat the question please? What the question was?

MR. STUTZKE: Okay. The issue is what can we do, if I understand by looking at these objectives --

MEMBER BONACA: I can repeat it. You gave us an example of defense in depth or examples. And then going back to what we heard before, which is the fact that we have increased the likelihood of having to rely on cavitation of the pumps in any one of these events. And that's the heart of the issue.

And I'm trying to understand the process where we should -- I mean there has to be some tradeoff for us to get there, okay.

MR. STUTZKE: Yes.

MEMBER BONACA: The tradeoff here is the convenience of the licensee to use his approach.

MR. STUTZKE: We believe with our new guidance that there are other tradeoffs being made.

MEMBER BONACA: Okay.

MEMBER RAY: Well, on that point, Marty, you were using tech specs as an example. And you are quite right. Nowadays, plants keep track in the daily report what the risk is during the day based on what is out of service. So it goes all over the place.

I guess the one observation I would make is having negotiated a few tech specs in my life, that the duration of that outage is strictly limited not to what is acceptable from a risk standpoint but what is necessary given whatever the component or device or system is to maximize the long-term assurance of performance.

So there is a dimension there which I think was implied by what Mario was saying, which is that I mean even things that have a tiny, tiny contribution to risk, you've got to keep the outage really short just because you don't want to allow any increase in risk more than is necessary for the maintenance of the item involved.

And I can give you battery chargers or lots of things where you've got these ridiculously short allowed outage times, all of which are just part of an effort that we all accept to keep the risk as low as we possibly can. So that's what I wanted to say in response to your comment.

MEMBER BONACA: Yes. And it is a design change -- it actually is a design change in which you are running those pumps in a configuration that wasn't designed to operate in that mode. So I'm trying to understand how it fits in defense in depth.

MR. STUTZKE: Okay.

MEMBER BONACA: I mean it's more like a design change. And what does it produce?

MR. STUTZKE: Yes, with respect to that, when I did the risk evaluation, I assumed if the required NPSH -- or the available NPSH was lower than the required, the pump has functionally failed. It's like it is turned off. Period. So it is not allowed to operate in a period of cavitation. I take no credit for that in the PRA even though I know the pump is running and it is probably working.

MEMBER RAY: Or that the operators don't throttle it back so it doesn't --

MR. STUTZKE: That's right.

MEMBER RAY: -- cavitate, which is another mitigating step here.

MR. STUTZKE: That's right.

MEMBER RAY: But -- okay.

MEMBER ABDEL-KHALIK: But that's sort of the assumption that you do deterministically.

MR. STUTZKE: Yes, it is. But I would argue -- let me go through the logic of this slide. And I have to apologize. There is a horrendous typo.

The last less-than sign is a greater-than sign.

MEMBER BANERJEE: Was that a Freudian slip?

MR. STUTZKE: No, that's what comes from working at midnight. I've actually seen that in License Amendment Requests where the LERF was bigger than the CDF. You go how can that be?

Okay, so to recap, the notion is, just the very use of a CAP credit effects the independence of barriers but it doesn't, by itself, make changes to programmatic elements. In fact, we want to think about changing certain programmatic elements or other ways of improving or ensuring we have adequate defense in depth.

And some of those are the fact that we've treated the thermal hydraulic uncertainties in both the available new required NPSHr. That's what Rich Lobel will talk to you in great detail this afternoon about how they quantified that margin.

DR. WALLIS: What is a programmatic element?

MR. STUTZKE: Things like inspections of the reactor coolant system, quality assurance requirements. All of these are elements of defense in depth.

DR. WALLIS: Okay.

MR. STUTZKE: And we're not -- the second part of our guidance and the heart of this risk evaluation that I've done will show you the influence of containment integrity testing on the increase in core damage frequency.

MEMBER ABDEL-KHALIK: What is L_a in words?

MR. STUTZKE: I'm going to let Rich define it.

MR. LOBEL: I'm sorry. I didn't hear that.

MR. STUTZKE: L_a.

MEMBER ABDEL-KHALIK: L_a.

MR. STUTZKE: The design basis leak rate.

MR. LOBEL: This is Richard Lobel from the staff. L_a is containment leakage rate when the containment is pressurized to the maximum LOCA pressure. That's the leakage rate over 24 -- mass leakage rate over 24-hour period.

DR. WALLIS: What unit?

MR. LOBEL: Assigned basis LOCA.

DR. WALLIS: What units are these?

CHAIR SHACK: Whatever units you want.

DR. WALLIS: Well, a leak rate must have units.

CHAIR SHACK: He's scaling it.

MR. LOBEL: It's a percent.

DR. WALLIS: Oh, it's a percent.

MR. LOBEL: So it's dimension-less.

MEMBER BROWN: You said over what time?

MR. LOBEL: Twenty-four hours.

MEMBER BROWN: You said it is the maximum amount? Or the average?

MR. LOBEL: It's the leakage rate in a 24-hour period, a percent leak -- percent of the mass that leaks at 24 hours.

DR. WALLIS: So how could it greater than 100 percent? How can it be greater than 100.

MR. STUTZKE: One hundred percent of the design basis.

DR. WALLIS: Oh, of the design basis.

MR. STUTZKE: Right it is a ratio of the design basis or the actual to the design basis.

DR. WALLIS: Okay. So a LERF would be tens of thousands or something? Or what is --

MR. STUTZKE: No, a LERF is roughly 100 L_a or bigger. There's different values one finds in the literature. I've heard as low as 35 and as high as 600. Like this.

DR. WALLIS: But a catastrophic failure

presumably is much bigger than that.

MEMBER ABDEL-KHALIK: This quantity here is an integral quantity.

MR. STUTZKE: Right.

MEMBER ABDEL-KHALIK: Over 24 hours?

MR. STUTZKE: Yes.

MEMBER ABDEL-KHALIK: Okay. Does the distribution of the leak rate make any difference on this result?

MR. LOBEL: I'm not sure what you mean by the distribution.

MEMBER ABDEL-KHALIK: In other words, if I have a very high leak rate early on that causes the pumps to fail, does it make any difference whether you have a uniform leak over 24 hours or you have a big leak early on that reduces the pressure in the containment and the pumps fail?

MR. LOBEL: L_a is really not a major contributor to the accident analysis. It is a really -- it's a pretty small contributor.

MEMBER ABDEL-KHALIK: But that's not my question.

MR. LOBEL: Well, if the leak was high enough at the beginning, I suppose you could lose the pressure and if somehow you stopped up the leak after that, you could maybe get this average -- you could maybe get this total over the 24 hours to come out to be the same number.

MEMBER BLEY: Rich, let me ask it a different way because I've got a confusion in this.

I think what we've asking is aren't we talking about the leak rate that could cause loss of NPSH is equivalent to that average leak rate over 24 hours.

MR. LOBEL: Yes.

MEMBER BLEY: On an instantaneous basis. But that's where you get the number, that's all.

MR. STUTZKE: Yes, the point of the argument is you need a smaller hole to lose containment accident pressure than you need to create a LERF necessarily. It's more likely you will get a small hole than a big hole. And so even if the sequence progresses to core damage, you are not necessarily going to suffer a LERF.

And that's different thinking. People have not credited that total.

CHAIR SHACK: Right.

MR. STUTZKE: Not necessarily, it is possible.

MEMBER BLEY: Not much to hang your hat on is it?

MR. STUTZKE: Okay. So we have performed our own risk evaluation of this with an eye on the clock here. The idea was to estimate the increase in CDF from relying upon containment accident pressure.

And we did this by using our SPAR models. We've looked at Browns Ferry and Montecello so far. Our SPAR models are what we use to drive the, for example, the significance determination process. They have been benchmarked against licensee's PRAs that have undergone peer reviews in accordance with the consensus standard. We've done two peer reviews of our own SPAR models and they compare reasonably well.

So the idea is for these plants, both main Mark I plants, is that I assume CAP credit is necessary whenever either the core spray pumps or the HRH pumps are drawing suction on the suppression pool. Okay, no assumption about winter versus summer in here. Just -- you need it. No assumption about numbers of pumps running or what the reactor power is, okay?

MEMBER ARMIJO: There is no assumption about the magnitude of the CAP credit.

MR. STUTZKE: I'll get to that.

MEMBER ARMIJO: Okay.

MR. STUTZKE: I'll get to that.

MEMBER SIEBER: Not yet.

MR. STUTZKE: Not yet. Of course our SPAR models are currently limited to internal events so a full spectrum of transients and LOCAs, we haven't yet looked at the impact on fires and seismic. We don't have adequate models to do that yet. Mainly the detailed table routing information to do a proper PRA that is lacking.

We don't have fragility information on seismic events that could create small leakages of the size we need. And even if I had the fragility information, I don't have a seismic PRA to use it in. So, you know, it is a catch-22. So it is a known limitation like this.

So to be specific, you guys, as usual, are a step ahead of me. The definition of the event loss of containment integrity in the PRA model means that you've got a hole big enough to prevent adequate NPSH. The first realization is I need to understand how big is the hole, okay. And the real way to go about it would be to use some thermal hydraulic tool like MELCOR or GOTHIC or SHEX to get a feel on that.

It's most likely plant-specific. The leak sizes that have been used in previous valuations we got from licensees at Vermont Yankee. They got a 27 L_a hole and that is the full-blown Appendix K treatment. They later said it could be up to 60 L_a if it was more realistic.

Notice there is a tradeoff here. If L_a is small, that means you don't have as much potential for a large early release. The larger L_a gets, the closer you get to the LERF criteria. So there is a little tradeoff.

At Browns Ferry, in their EPU submittal, they used 35 L_a.

MEMBER RAY: Marty, did I understand -- I don't want to bog you down here but we're talking just -- we're not considering an external event as a cause of --

MR. STUTZKE: That's correct.

MEMBER RAY: -- a containment leakage?

MR. STUTZKE: That's correct.

MEMBER RAY: Even though most of us, that's the first thing we think of.

MR. STUTZKE: Yes. The problem is the staff doesn't have a good set of external event PRA models. But we do have some SPAR -- they are called SPAR external event models for some of the plants.

MEMBER RAY: Well, this is all very

interesting but I mean with that sort of hanging in my head, I can't think about it very easily because it's like I set aside the most important circumstance.

CHAIR SHACK: Aside from that, Mrs. Lincoln, what did you think of the play?

MEMBER RAY: Right. Okay. All right. Go ahead, I'm sorry.

MR. STUTZKE: I'll come back to that thought.

So I just picked 20 L_a as kind of a lower edge to this. There's no rhyme or reason. There's no thermal hydraulic behind it. I'll show you how it can be readily adjusted.

We considered three different time frames when the containment could leak. It could be before the initiating event, when the initiating event occurs, or after the initiating event occurs, okay, and all of these are in the model.

The pre-initiator leak probabilities, in the previous risk evaluations that licensees did was they went to this EPRI document that was developed to support extending integrated leak rate test intervals. Okay.

And they went down and they picked out what size of leak they thought they needed, be it 35

L_a or whatever. And they read over in the table and they used these numbers. And they put them into their PRA. So kind of a monolithic failure probability of preexisting leaks.

At the same time --

MEMBER ABDEL-KHALIK: Excuse me, Marty, what are the units of these numbers in the first bullet?

MR. STUTZKE: They are pure probabilities. It's the probability that a preexisting leak develops.

MEMBER ABDEL-KHALIK: Okay.

DR. WALLIS: For a year?

MR. STUTZKE: No, just the probability.

DR. WALLIS: You can't have a probability without some time involved.

MR. STUTZKE: That's the troublesome thing.

DR. WALLIS: Well --

MR. STUTZKE: Yes. These are the troublesome things. And you'll see how I got around it -- what I did about it.

DR. WALLIS: Because if it is in a microsecond, we're in trouble.

MR. STUTZKE: One of the difficulties is that when you base these sorts of numbers, these preexisting leak probabilities, the probability that a leak exists when the initiating event occurs, on these types of numbers is that you ignore other ways that one could detect containment leakage.

And licensees are fond of telling us gee, but we would know because we would be blowing nitrogen like crazy into the containment trying to keep up with that or our oxygen concentration would go squirrelly and we would detect it. Some licensees actually have differential pressure alarms that come off when you get a delta P between the wetwell and the drywell like this. And yet none of that was being credited in the previous risk evaluations. And we wanted to get after it and see what we could do.

The other issue that comes up is that when you're testing things like containment leakage is we know the test is not perfect. And sometimes it doesn't find the leaks or it won't find the right size of leak with this.

So we wanted some approach to expand it. And the approach was to develop what's known as a semi-Markov model that handles all of this alphabet soup.

MEMBER BLEY: Marty?

MR. STUTZKE: Yes?

MEMBER BLEY: Before you go on, I've been a little confused and I think I've got a handle on it. But let me say what I think.

I was a little confused why we are using the licensed leak rate for this. And it is not because that has a direct tie in principle to when you would lose net-positive suction head, I think, because that could have been anything. Physics do the other one.

It's because you are hoping and other people have tried to anchor the likelihood of a preexisting leak to monitoring of leakage associated with tech spec requests.

MR. STUTZKE: Exactly, exactly. That's the strategy here. Okay.

So I hypothesized a technical specification that looks like this. This one is actually patterned after the primary containment O_2 concentration that already exists. But it says something like this. If the leakage rate is at or above the magic number, and here 20 L_a, reduce it. And you have time, T_{ST}, in which to do so. In my base case, that's 24 hours. That's what this tech spec says.

If you don't get the leakage below that, shut the plant down. And you've got another eight hours in order to get the plant shut down. Okay. What that says is that once a leak is detected, there is at least a 32-hour window before the plant would -- up to a 32-hour window while the plant could be operating with a known leak that would defeat the containment accident pressure credit. Okay.

The other part of the tech spec, it says you would verify containment leakage. And that has a surveillance test interval. For this one, the nominal case is seven days. And I will show you a full sensitivity study. We played with all of these numbers because I knew you would ask.

MEMBER BLEY: I take this is hot off the press. You don't have a report on this stuff yet.

MR. STUTZKE: No, I'm writing furiously.

MEMBER BLEY: Okay.

MR. STUTZKE: I've got other -- we'll talk about that.

So when you get down to determining this, it turns out the important parameters are leakage failure rate itself, lambda, the mean time to repair the leak, the surveillance test interval, how much time you are going to allow the licensee to try to fix the leak while the reactor is still operating, how much time you want to shut the plant in, and then finally what is known as test sensitivity, probability that the test doesn't find the leak.

DR. WALLIS: These are all pre-event leaks?

MR. STUTZKE: Yes, this is only the pre-event leakage calculation.

Now knowing that you guys are not confused about containment accident pressure, I thought I would throw up my confusion matrix, just a classic from statistical hypothesis testing.

Across the top you see the actual containment condition, whether it is leaking or whether it is intact, true or false. On the lefthand side, you see the test result. Did the test indicate it was leaking or is it intact?

This type of thinking and hypothesis testing is very common in medical tests. Okay. This is the one that says gee, if one percent of the population has H1N1 virus and my test is 99 percent sensitive and I feel bad and I go to the doctor and I get the test and he says yes, the test was positive, what is the probability I'm really sick? In that case, 50 percent, not very good, okay.

So we have the notion of false positives where, in this case the way I've set up the matrix is the containment is intact but the tests would indicate it is actually leaking. Okay. That's an operational problem because they'd have to go chase that down but, in fact, the containment is intact.

But the worst one for us, as far as safety, is the false negative where there is actually a leak and the test says everything is okay. And, therefore, there's no remedy like that. So we're interested in what is called the sensitivity of the test as opposed to its specificity.

Now I got asked when we were dry-running this presentation what is a semi-Markov model. And to answer that, we'd probably sit here for two semesters like I did in an advanced probability theory. But let me try to give you an idea.

The system is in one of a number of discrete states. So the containment is intact. Or it's leaking but we don't know that it is leaking. Or the leak has been found and we are furiously trying to repair it. Or we don't get that done and now we have to shut the plant down and go fix it. Those are discrete states like this.

The probability of transitions from one state to another only depends on its current state.

It doesn't matter how it got there. It just matters where it is. This is the fundamental that is called the Markovian property that makes this process work.

MEMBER BLEY: And these first two describe any Markov process.

MR. STUTZKE: That's true. What makes it semi-Markov is the idea that it waits in a given state for a random period of time with an arbitrary distribution. Okay.

MEMBER BLEY: What do you mean by arbitrary?

MR. STUTZKE: Whatever you want. If I fixed all of the waiting times, in special cases like this, if they are all fixed and they are equal, we call that a Markov chain. So daily sorts of things.

If we allow the waiting times to be exponential, which is typical in risk assessment work, then it is called a continuous time Markov process. The reason why I had to use semi-Markov is the tech spec is not exponentially distributed. It's not fixed and constant. I have all kinds of things going on. And so okay. The difference doesn't really matter that much when you look at the average.

The classic analogy that I learned in school from my math professors, when you think of a

Markov process, think of a lake. And the lake's got lily pads on it and there is a frog sitting on one of the pads. And he sits there for a while. And then he jumps to the next one. And he sits for a little while and he jumps back or he goes to the third one. And so it is this bouncing around from state to state with different probabilities and different amounts of time the frog is sitting on the lily pad. Okay.

Let me walk you through the semi-Markov model that I actually built. Whenever people see the whole thing, they tend to choke. Okay. So let me walk you through it.

We'll start out with State 1, which is the containment is intact. And by the way, in all of the states, the reactor is actually operating. It's critical; it's making power. Okay.

Now we consider some possibilities here. The leak occurs with some probability. If it does, it transitions to a new state, number two, the undetected leak state. Okay.

Alternatively, the leak doesn't occur. It's probability one minus P. Once it is in state number two, eventually a surveillance test is run and the leak would be detected. And here is our Type II error coming from the confusion matrix which is probability of one minus beta.

And if that test indicates there is actually a leak, the action statement of the tech spec is entered. And the licensee would attempt out power repair. That's our new State 3.

Some chance the test doesn't work. It's not effective. So the leak is not detected and it continues to remain in the undetected leak state. There is a chance while the reactor is still operating that they get the repair fixed within the tech spec allotted time and it returns back to State 1.

There is also a chance where they think they fixed the leak but they didn't really. So it returns back to the undetected leak state. There is a chance here where now you run out of time. The tech spec expires and the plant has to enter a transition into shut down mode. Eventually --

DR. WALLIS: Well, some of these probabilities are intervals of time and some are just probabilities, aren't they?

MR. STUTZKE: That's correct.

DR. WALLIS: So they're not congruent. They're different things.

MR. STUTZKE: Well, this leak detected, these are all pure probabilities.

DR. WALLIS: But the leak occurs is some interval of time, isn't it? Or is that --

MR. STUTZKE: No, it's the probability actually that the leak occurs over the surveillance interval.

DR. WALLIS: Over that interval. It's got to have some time in it somewhere.

MR. STUTZKE: Right. Right. And I gave you -- there are some backup slides that have got all the algebra if you're interested like that.

But anyway, so there is some chance that at power, you know, that they get down to transition, to shutdown, they think they repair the leak. They start back and, in fact, the whole is still there like this.

DR. WALLIS: And of course you have a very good idea where all these areas are.

MR. STUTZKE: Pretty good. Well, the point is the probability of a preexisting leak is it is a long-run fraction that the system is residing in either State 2, 3, or 4. Okay. That's the reason why you go to all of this.

Either it's leaking and we don't know it's leaking, or it's leaking and they are trying to repair it. And during that repair activity, lo and behold they get a LOCA and they need it to work and they know it's not going to work. Or the tech spec expires and they are trying to transition to shutdown. Maybe they, you know, shutdowns are stressful on systems and maybe the LOCA occurs like this.

So, okay --

DR. WALLIS: Well, some of these are real leaks and some of them are valves left open, aren't they? I mean it's different kettle of fish.

MR. STUTZKE: Valves are another part of the model.

DR. WALLIS: You can fix those but I mean if you've got a hole in containment, then fixing it is not a trivial thing.

MR. STUTZKE: That's right. Yes, they may not be able to fix it.

MEMBER RYAN: In mean in reality probably what you have for the containment intact and a leak occurs, it is not just one probability. It's probability I'm guessing a couple dozen pathways out of leak occurs. So this is one layer of probably a very complicated --

MEMBER BLEY: Or this is a condensation effect.

MR. STUTZKE: Right. It is a

condensation.

MEMBER BLEY: Yes.

MR. STUTZKE: For example, we determined that the lambda for a 20 L_a leak is on the order of ten to the minus seven per hour. That comes out of some data that people collected that says here is how often plants fail integrated leak rate testing.

MEMBER BLEY: No, I'm just curious. The slide you showed earlier of the two cases you had looked at where licensees had used the old EPRI report had probability that differed by a factor of two to three.

MR. STUTZKE: I'll show.

MEMBER BLEY: Are you going to talk about that?

MR. STUTZKE: Yes, I'll show you where they stack up --

MEMBER BLEY: Okay.

MR. STUTZKE: -- because it is almost spooky sometimes.

And so we got these leak rate distributions, so forth and so on.

MEMBER BLEY: So this first one is based on data essentially?

MR. STUTZKE: Yes. These are the results

of the preexisting leak. And the reason why you see a family of curves here is that we went after the fact we didn't know some of the parameters very well and we did some sensitivity studies. But basically you get this characteristic shape like this.

DR. WALLIS: Units of time are --

MR. STUTZKE: These are per hour. Excuse me, the surveillance test interval is per hour.

DR. WALLIS: So ten to the six hours between tests? Is that reasonable?

MR. STUTZKE: Well, we extended it all the way from a once per hour test, as indicated by the labels on the plot, all the way up to one test in 15 years, which is the current ILRT. Remember one of the things when we developed this semi-Markov model is we were not only looking at BWR Mark Is but we realized PWRs might want to avail themselves. And this model is flexible enough it will handle everything in here.

The current ILRT rate, you know, of three in ten years like this, annually, monthly, right in the middle of the plot here is once per week, which corresponds to the oxygen monitoring that currently goes on in containment. And what you basically find is once you get beyond once a week, it is only sensitive to the surveillance test interval. It is not sensitive to the other parameters, the probabilities of Type II errors, the tech spec.

MEMBER BLEY: This one number off of these curves is for one set of all these parameters. And that number is the stationary state of your Markov model?

MR. STUTZKE: That's what I call the base case. All of these are steady-state solutions.

MEMBER BLEY: Okay.

MR. STUTZKE: Okay. What the base case says is once the leak occurs, they have 24 hours to try to fix it. If not, you shut down in eight hours, lambda ten to the minus seven tau. So that is the base case. So I had my associate put it on because I couldn't remember it.

DR. WALLIS: And the slope of the line is one there?

MR. STUTZKE: That's a good question.

MEMBER BLEY: On a log-log.

MEMBER BROWN: You said once it got past one week or longer than one week, it wasn't sensitive? Or do you --

MR. STUTZKE: Yes, you see where you get beyond here at one week --

MEMBER BROWN: Well, it keeps going up.

MR. STUTZKE: Well, it goes up. It's not sensitive to the other parameters other than surveillance testing.

MEMBER BROWN: Oh, oh, other than surveillance. I'm sorry

MR. STUTZKE: Right.

MEMBER BROWN: I misunderstood you. I got it.

MR. STUTZKE: It's the sensitivity to the leak failure rate. And basically it goes up by the same factor. We did two cases of minus seven and minus six to try to get a feel for it.

The other thing we did with this semi-Markov model is we actually built a little Monte Carlo tool and we ran it to simulate the process going back and forth.

MEMBER BLEY: First time since school?

MR. STUTZKE: No, fortunately I have a guy that just got out of grad school that knows how to write Visual BASIC very efficiently. So we did ten to the eighth trials.

Okay. Here's the leak upon the initiating event, the containment isolation consideration. For this type of plant, the Mark I containment during routine power operations, there are no pathways open between the containment and the atmosphere. If there were, the nitrogen would go someplace.

Pathways exist while the plant is being inerted, right after startup, and while the plant is being de-inerted like this. So basically we weighted the probability of a containment isolation system failure by the time when it really mattered. Okay.

The two days in the whole fuel cycle like this. That's probably a little optimistic. Maybe it's three days, maybe it's four days. But it is clear it is not that the containment isolation system doesn't always have to work. That's the point here. And that had been assumed before in previous risk evaluations that licensees had done.

There is one other sneaky path going on in here and that was raised to us during the Vermont Yankee EPU. And the notion is this. That if you had a LOCA and you failed to shut the main steam isolation valves, you could depressurize the containment backwards through the steam pipe out the valve and into the plant. Okay. That was the concern.

So I actually introduced that into the model for all the LOCAs, not just the double-ended large LOCA like this. It turns out it is a very small contribution mainly because MSIVs are pretty reliable.

This is the probability that they all fail, including all the independent, all the different common cause combinations there. That's ten to the minus four.

Okay. To get to --

DR. WALLIS: This includes operator action or is it --

MR. STUTZKE: This is all automatic.

DR. WALLIS: It's all automatic?

MR. STUTZKE: Yes.

MEMBER ABDEL-KHALIK: So you don't need all of them to fail.

MR. STUTZKE: You just need one steam line to -- yes, you just need -- actually you need two valves to be open.

MEMBER ABDEL-KHALIK: Right.

MEMBER BLEY: Marty, help me out with your -- I guess it's the first one -- the time periods in which this can occur. When you are in power operations, the reactor building is closed up, I guess. But it could be open.

MR. STUTZKE: It could be open because sometimes they --

MEMBER BLEY: If it is open, you'd know it right away but you'd still have that 32-hour exposure period.

MR. STUTZKE: Only if -- it depends on how you'd write that tech spec, you know, you're deliberating opening it up for certain reasons.

MEMBER BLEY: Yes.

MR. STUTZKE: You know you would have to be able to get around that.

MEMBER BLEY: Go ahead. I've got to think about that a little.

MR. STUTZKE: Yes.

MEMBER BLEY: It looks like you're missing a piece.

MR. STUTZKE: Yes, there could be. And I'm no expert on tech spec language like that.

The other one that has come up repeatedly in our discussions of containment accident pressure is a little amount for a short amount of time. Okay. Post-initiator leak probability is where that show up at least in part. It's called the mission time of the PRA. And so what I assumed was we are interested in leaks that happen up to 72 hours of the occurrence of the initiating event.

If the licensee did a calculation and said gee, I only need containment accident pressure for the first 12 hours, I'd change that 72 to 12. It's the only parameter in the model that is sensitive to the mission time, okay, to the duration over which containment accident pressure is needed.

These others, the pre-initiator leak and the upon initiator leak probabilities, of course, are insensitive to the duration.

CHAIR SHACK: Of course now you've assumed your leak rate during the accident is the same as it has been all the time.

MR. STUTZKE: That's right.

CHAIR SHACK: Which probably --

MEMBER RAY: Well, again, we're excluding external events, Bill, which, you know, I can't get my mind around that.

MR. STUTZKE: Yes.

MEMBER RAY: And the most likely breach of the containment is going to be a seismic event.

MR. STUTZKE: When you put all this in, we generate the following plot. Surveillance test interval in hours on the x axis. This is the change in core damage frequency per reactor year. This is delta CDF. You see the different contributions with different colors. The black line is the sum of all of the contributions.

Again, some labels to indicate how often the surveillance test is, you know, whether it's once a month, once a week, et cetera. These arrows on the right-hand side correspond to the labeled regions in Reg Guide 1.174 for risk acceptance guidelines.

That Reg Guide says delta CDF below ten to the minus six is called a very small change. Between minus five and minus six is a small change. And above minus five, we would not normally accept.

And so you get this type of result. There are some interesting insights you can ferret out of this. First of all, once you get testing more frequent than once a week, it doesn't really effect the delta CDF because it goes asymptotically horizontally flat like this.

On the other hand, when you get up to large surveillance test intervals around ILRT time, three in ten years, once in 15 years, if that is the only way you have of confirming containment integrity for CAP credit, it is probably unacceptably high change in risk.

MEMBER ABDEL-KHALIK: Bit is a one-per-week inspection frequency a reasonably realistic --

MR. STUTZKE: Well, that's how often they test for oxygen in the containment now. That's how often some plants monitor nitrogen mass balances. Okay. The issue here -- in other words, and again I'm no expert on how to test containments, my feeling is for the Mark I containments that are inerted for plants that have sub-atmospheric, they are probably already doing enough to be helpful to us like this.

Again, the whole point of the confusion matrix and looking at the test efficiency was you don't need that good a test. It doesn't need to be that accurate to find a hole of the size we're talking about. Okay.

It's different than an ILRT when you are trying to measure something extremely precise. Okay. So the idea here is if I test more often, my test doesn't need to be of highest quality.

MEMBER BANERJEE: Is there a sort of uncertainty on this change in CDF?

MR. STUTZKE: Yes.

MEMBER BANERJEE: How much is that?

MR. STUTZKE: I haven't computed it.

MEMBER BANERJEE: You are going to do that?

MR. STUTZKE: Yes. No, I haven't done it yet and the reason is I need to decide appropriate uncertainty distributions for everything in the model. The failure rate, that's pretty easy. We do that all the time in PRA. And the same thing for the mean repair time.

The real problem is what sort of uncertainty do I put on the other parameters of the model? I'm not even clear what an appropriate uncertainty distribution would look like for testing efficiency.

I mean is it log normal? Is it normal? We haven't done the work yet. Rather the approach was rather than a full-blown parametric Monte Carlo approach, to try to treat it with sensitivity studies and see did it really matter a great deal.

MEMBER BANERJEE: But even with that, you would need some sort of a distribution rate.

MR. STUTZKE: To be complete, I would agree.

MEMBER BANERJEE: Yes.

MR. STUTZKE: I would agree.

MEMBER ABDEL-KHALIK: So would this be a new tech spec that you would require that if you detect a leak of a given size, as long as you do the testing once a week --

MR. STUTZKE: That's one way to do it.

MEMBER ABDEL-KHALIK: -- then you have to shut down --

MR. STUTZKE: The other way would be to

utilize -- I think licensees could utilize an existing tech spec. I think they could make a case. What bothers me or what I don't know is that if you utilize an existing one, for example oxygen concentration, okay the tech spec is four percent. And the reason why it exists is that you don't want to have hydrogen explosions.

MEMBER ABDEL-KHALIK: Right.

MR. STUTZKE: Okay. I don't know four percent oxygen concentration in a containment equals a hole of this big a diameter, you know that's a pretty obtuse relationship curve.

MEMBER RAY: Well, Said says such a tech spec would be relevant to the stuff Marty's looked at is good insights here. I don't see how you would write a tech spec that would pertain, for this purpose, that would somehow not be applicable to a design basis event like an earthquake.

If you're talking about CAP credit and the probability of a containment leak effecting your ability to get CAP credit, how can you set aside the major reasons why you are going to need CAP credit in the first place? That's why it's -- I mean I appreciate this. It's really good and helpful insight.

But it is hard for me to translate that into well what the heck do you do with the plant because we're not looking at what we all tend to think of, maybe wrongly, as the circumstances in which CAP credit is most likely to be required. That's an event that could be called --

CHAIR SHACK: We've ignored, too.

MEMBER RAY: -- rather than just a crack in the pipe and we'll assume an accident.

MR. STUTZKE: The fire personally worries me worse than the earthquake.

MEMBER RAY: That's a fair point. I mean I take it -- I'm from California. You're from the East Coast.

MR. STUTZKE: Multiple spurious actuations due to fire has been a big deal in NFPA 805. We continue to wrestle with that issue.

I'm also one of the head analysts for Generic Issue 199, which is increased seismic hazards. So I can speak to that.

But to answer your question, yes, the analysis is not complete. And I don't know where else I can go without having full fire PRA or a full seismic PRA.

MEMBER RAY: This is good. Don't get me

wrong. I'm not criticizing.

MR. STUTZKE: Not to let the cat out of the bag but I have an SRM now from the Commission that says go forth and update NUREG-1150. Just tell us how to do it. And we are in the process of planning. And that is a full-site comprehensive Level 3 PRA that would include all of the reactors, including multiple unit interactions, and all of the spent fuel on site. One study.

MR. RULAND: That's job security.

MR. STUTZKE: That's why I've been a little busy guys.

MR. WOJCHOUSKI: Hello. This is Alan Wojchouski. I'd like to make a kind of statement on your tech specs.

MR. STUTZKE: Yes.

MR. WOJCHOUSKI: Currently Montecello and a lot of the BWRs have tech spec on L_a, one L_a, if you are above that, you've got one hour to restore it or in 12 hours to go ahead and shut down.

So basically what we have to do on that is we monitor it. And the one way that we can monitor -- this is not a tech spec requirement but Montecello has a low pressure alarm in a control room. So that if the pressure inside the drywell or containment is less than .1, you'll get an annunciated alarm. It's also the same alarm that will give us a high level pressure alarm at one and a half.

So basically it is continuously monitored. And if you are talking about a leak the size of 20 L_a or 30, whichever, you are talking a very large leak and you will not be able to make that up with your normal make-up capabilities. So the control room will be aware of that really fast.

MEMBER BLEY: Just to help me think about it, is the nitrogen always supplied? Or do you apply it and cut it off and then if you lose pressure, add it again?

MR. WOJCHOUSKI: Most of the BWR Mark Is have a make-up system in which it can be put in service to maintain the pressure. Montecello, we have a nitrogen system which we have a liquid tank outside, goes through a vaporizer, and that's what supplies our normal instrumentation inside the drywell.

MSIV, solenoid valves, actuators, and diaphragms, what we found out is that just a small leakage through some of those fittings, because they are at 100 pounds, is enough to maintain the containment atmosphere positive.

And how we actually control what the

pressures are is we have a continuous air monitor in which it pulls sample off the containment, runs it over filter paper to find radionuclides on it, to estimate any leakage inside of it. And we can either pump that right back into the containment to maintain the pressure or we can put it off to our reactor building plenum, which will go ahead and reduce the pressure.

So typically what happens is if you're losing pressure, we'll put it right back in the reactor vessel containment. And if you're hitting high pressure, you can go ahead and put it off on the plenum.

MEMBER BLEY: I guess what I'm thinking is you might never hit one of the alarms but you might gradually over some months ramp up the rate of nitrogen feed or something. I don't know that on a daily basis you'd actually --

MR. WOJCHOUSKI: That would be something each licensee would have to look at. At Montecello, the last time we actually did the make up was in 2005.

MEMBER BLEY: So it's certainly time, okay.

MR. WOJCHOUSKI: Just some insights into what's out there right now.

MR. STUTZKE: Thank you.

So, looking at the clock, one of the qualitative insights is there is only one minimal cut set, one accident sequence with a loss of containment integrity. It goes directly to core damage. And that's the large LOCA sequence.

All the other cut sets have multiple failures involved in them. Okay. So there's defense. There's defense in depth, there's redundancy like this.

MEMBER BANERJEE: Well, Marty, I have a question to ask you.

MR. STUTZKE: Yes?

MEMBER BANERJEE: This is a sort of a specific scenario. But imagine that I look at it somewhat differently and say that I am concerned about, for example, sump strainer blockage or something, take that just as an example. The reason I need this sort of overpressure is to take care of my uncertainties, margins, and things like that.

That could be a scenario where I would get core damage. Perhaps it wouldn't matter because the containment integrity would still be preserved.

But if I wanted just to limit core damage, then that sort of margin that I have there is useful to me for all the unknowns about something where I don't know things, you know, that well. And strainer blockage is one. And I can probably think of a couple of others. So how does that get factored into this risk assessment?

MR. STUTZKE: Well, in the PRA like this, the strainer blockage would be a separate basic event in my model to a loss of containment integrity. And they both would have the same functional effect on the system. And though their likelihoods of occurrence could be different --

MEMBER ABDEL-KHALIK: But if you don't know it, you can't have it in your model.

MEMBER BANERJEE: Well, you can put uncertainty on it, right?

MEMBER ABDEL-KHALIK: Well, I mean this is sort of --

MR. STUTZKE: There are failure modes that we don't model in PRAs because we're not smart enough to put them in there. The so-called unknown unknown. And the mitigation for the unknown unknown is defense in depth.

MEMBER ABDEL-KHALIK: Correct.

MR. STUTZKE: Okay. That's what NUREG-1855 tell us like this.

MEMBER BANERJEE: But we know about strainer blockage. We know a lot about it.

MR. STUTZKE: Yes. But the Committee has been right over the years. Dr. Powers has always asked what if you're wrong? What if you forgot something. You know the PRA can only model what it knows to model.

DR. WALLIS: But it doesn't model events which could cause both a LOCA and the leak.

MR. STUTZKE: It could. But it doesn't.

DR. WALLIS: It doesn't.

MR. STUTZKE: You mean like the big earthquake, things like that.

DR. WALLIS: Or other imaginable events.

MR. STUTZKE: I mean my argument on the seismic is if I had a big earthquake that would create a LOCA, okay, and failed the containment, most likely the low-head ECC pumps are already failed anyway. And they don't care whether they have overpressure.

MEMBER RAY: Well --

MR. STUTZKE: You know just looking at the relative HCL PF values.

CHAIR SHACK: But fire is a different beast.

MR. STUTZKE: Fire is a different beast.

Anyway, so you get these contributions like this. The pre-initiator seems to be the largest one. I think the graph is a little bit more illuminating because you can see how it functions as a function of surveillance test interval.

Something I actually learned doing this was we always do importance measures, Fussell-Vesely and Risk Achievement Worth and in our standard, that's how you decide whether something is significant or not -- the Fussell-Vesely is bigger five E minus three or the RAW is bigger that two, then it is significant.

Well, what I found here was it didn't matter what parameters I put into the model, the events were always significant. So I did a little arithmetic and I found out why that could be. It's very interesting insight.

There are some basic events that structurally are so significant that the numbers the go into the PRA model become irrelevant. So this is always going to be a significant basic event.

The major sensitivities seem to be the containment failure leakage failure rate, the surveillance test interval like this. This is a breakdown of the contributors by all the different initiating events and so forth and so on.

There's not a big change in the risk profile as indicated by the relative percentages here like this. Some of the initiators did go up considerably, the loss of service water, the loss of plant control there. But you would sort of expect that. Loss of service water is a pretty severe transient.

CHAIR SHACK: Yes. But what does it mean no CAP credit and with CAP credit? I couldn't figure that out.

MR. STUTZKE: Okay. This is assuming I don't need a CAP credit. The column is labeled no CAP credit. With the CAP credit was assuming I need one. And so it actually models -- this is like it models the loss of containment integrity in here. So it is all of these failure modes plus loss of containment integrity is in here.

MEMBER BLEY: Okay.

MR. STUTZKE: Does that makes sense? It's like a before-license amendment and an after-license amendment sort of snapshot.

And so this three E minus eight is the actual delta CDF for the base case. And that is what we would compare to Reg Guide 1.174.

MEMBER BROWN: So the numbers look low

from a math standpoint. And I know it depends on your intuitive --

MR. STUTZKE: Yes.

MEMBER BROWN: -- look at the circumstances as to how you --

MR. STUTZKE: Yes.

MEMBER BROWN: -- you fall back to judgment there.

MR. STUTZKE: To me when I see a delta CDF this small, I immediately think the uncertainty and the whole calculation is going to overwhelm any perceptible delta.

MEMBER BLEY: And what you've left out.

MR. STUTZKE: And what I've left out. You know that is somewhat --

MEMBER BROWN: And it also doesn't factor in Harold's thought relative to if you had an external initiator.

MR. STUTZKE: Right. Seismic or a big airplane crash or --

MEMBER RAY: Yes, to me the fragility of the containment is much different than that of a pump, having tested lots of pumps. And so I'd count on the pumps even if the containment fails.

MEMBER BANERJEE: But you have to break a pipe as well somewhere.

MEMBER RAY: You do. You have to. Understood.

MEMBER BLEY: And they are generally hard to break.

MR. STUTZKE: Okay. So that's where I am now. Clearly it's significant. It's an important type of event like this. It looks like with adequate testing, we can control the delta at least from internal events to some low level.

I'm not quite certain how to progress with respect to fire. The staff's guidance talks about a deterministic approach to treating the fires like that. There is reasonably nothing we can do in short order in the PRA field to get more information to treat that.

Any further questions?

MEMBER SIEBER: Good presentation.

MR. STUTZKE: Well, thanks. It was fun.

CHAIR SHACK: If there are no additional questions for Marty, I think it is time to break for lunch. Half an hour. So ten of.

(Whereupon, the foregoing matter went off the record at 12:23 p.m. to be reconvened in the afternoon.)

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

(1:00 p.m.)

CHAIR SHACK: Okay, I would like to come back into session. Our next presentation is from Rich Lobel of the NRC on the guidance.

MR. LOBEL: Good afternoon. My name is Richard Lobel. I am a Senior Reactor Systems Engineer in the Office of Nuclear Reactor Regulation and I would like to talk about the staff guidance that we are working on for the use of containment accident pressure and determining available NPSH.

Sitting next to me is Ahsan Sallman from the same branch and office. He gave a presentation earlier.

Before we start, I would suggest that it might be helpful to explain the nomenclature we have been using in accident pressure and overpressure. We started trying to use the term containment accident pressure because overpressure had some confusion and some connotations to it that weren't helpful.

Overpressure kind of implies that something is being overpressurized and in this context, it is not. The containment is not being overpressurized. There is no system component structure that is being overpressurized. And another reason we didn't want to use overpressure is that it had several definitions, depending on which licensing was using it. It was a pressure greater than atmospheric pressure; the pressure greater than saturation pressure; the pressure greater than the containment pressure prior to the accident; and the BWR Owners' Group topical report used the first definition, greater than atmospheric pressure.

So, we have used the phrase use of containment accident pressure in determining available NPSH, which is a little cumbersome.

The containment accident pressure is simply the pressure in the containment during a postulated accident.

This slide illustrates the approach the staff is taking. We have made estimates of the uncertainty of both the available and the required NPSH for UCCS pumps in a BWR-4 with a Mark I containment. And that method can also be applied to other reactor designs.

And estimate of the uncertainty in the required NPSH includes both the uncertainty and the required NPSH determined at the pump vendor's facility and the uncertainties expected for an installed pump, which we are calling the installed or field uncertainties.

We have called the NPSHR, including uncertainty, the effect of required NPSH, which is a little cumbersome, too.

The uncertainty in the available NPSH includes the uncertainty and the calculation of the containment conditions, the containment conditions are input to the determination of the NPSH. For both the required and available NPSH, a realistic value is determined for the available NPSH. Conservative and statistical values are also determined.

The difference between the conservative available NPSH and the effect of required NPSH is the conservative NPSH margin, which we will use for postulated design basis accidents. There is also a margin between the realist required NPSH and the realistic available NPSH, which was used for non-design basis accidents.

MR. WALLIS: Excuse me, Rich. When you say realistic, nominal, and statistical, which is that of the curve here? It is the --

MR. LOBEL: It is the bottom curve, the bottom straight horizontal line.

MR. WALLIS: No, the top very highest curve is the one I am asking about.

MR. LOBEL: Oh, okay. That would be --

MR. WALLIS: Is that the 95/95 or is that the mean?

MR. LOBEL: No, there isn't a 95/95 on here per se. The top one would be what we are calling the realistic or the nominal.

MR. WALLIS: Well what does that mean?

MR. LOBEL: The next one down, when we include the uncertainty in the nominal value, that makes it less for conservatism. We subtract the uncertainty and so that is the conservative. And I will show you later on that the conservative and the 95/95 are very close together.

MR. WALLIS: So nominal is placed on what?

MR. LOBEL: Nominal would be the value we would try to calculate. We would calculate with trying to make the most realistic values we can, for the most part. They would be 100 percent power.

MR. WALLIS: But you can't make a realistic value for the water temperature in the river because it varies.

MR. LOBEL: Right. And what we did for that, which isn't in the title is that we used the conservative value. So nominal isn't nominal for everything. It is not nominal for the service water temperature and it is not nominal for the head loss across the strainers. Those are the two things that -- because we don't know what a nominal value is for head loss and didn't try to calculate one. And the service water temperature like we were talking about this morning, we just assumed it was the conservative value.

CHAIR SHACK: The bounding scenario with realistic inputs for the analysis of the scenarios.

MR. WALLIS: Right.

MR. LOBEL: Okay, so this is just an illustration of the approach we are trying to take.

MR. WALLIS: What is the regulatory requirement here? That the margin be some value for some time?

MR. LOBEL: Thank you. I did mention that. No, we are not putting any restriction on the margin because we have included the uncertainties in the required and in the available NPSH. And we are talking in terms of NPSH. Because like I was saying this morning, we are trying to concentrate on the pump. Is the pump going to be able to do its job?

And so we are not so much interested in the bottom line looking at the containment pressure or the suppression pool temperature, that kind of thing.

They go into the calculation of available NPSH but we are trying to look at the NPSH margins at the final answer.

MR. WALLIS: But in order to run the plant, they have to show that the conservative curve is above the dashed line. Is that what they have to do?

MR. LOBEL: Yes.

MR. WALLIS: And the size of the margin is irrelevant.

MR. LOBEL: Yes.

MEMBER BLEY: Your paper, as I recall, says even though it is a 95/95 you think the conservatism and the calculation are sufficient that the margin is adequate if you are right below. Did I read that correctly?

MR. LOBEL: Not below the effective required.

MEMBER BLEY: I'm sorry, above. If you are okay but just by a hair, you are still okay, --

MR. LOBEL: Yes.

MEMBER BLEY: -- even though it is a 95/95 because of the conservatisms elsewhere.

MR. LOBEL: Well, because we have included the margins in those two calculations but yes.

MR. WALLIS: No, 95/95, as I understand it, doesn't come into this at all. It is just conservative.

MR. LOBEL: I'm sorry. You are right. We are talking about conservative. Like I said, I will show later that the 95/95 and the conservative are almost the same line.

MR. WALLIS: The regulatory basis is the conservative.

MR. LOBEL: Is the conservative.

CHAIR SHACK: Well, your Guideline 1 on slide four says you can use either.

MR. LOBEL: Yes, because they are so close together.

CHAIR SHACK: So close.

MR. WALLIS: Now wait a minute.

CHAIR SHACK: To be precise, you can't use both, according to the guidelines.

MEMBER ABDEL-KHALIK: But is that consistent with the results that we saw this morning.

MR. WALLIS: But what you said this morning --

MEMBER ABDEL-KHALIK: What we saw from the applicant this morning.

MR. LOBEL: No, it is not consistent

because the topical report, in a way, is old news now. It was started a couple of years ago and our SER was written before we even started working on this. So, I believe somebody from the Owners' Group said this morning that when we get to the point where we have guidance that is ready to be finalized; there will probably be a supplement to the Topical Report that will include the guidance.

We talked about that a little with the Owners' Group but we haven't reached any final conclusions about how to do this. But what we are proposing to do is from now on forward fitting the staff guidance would be used.

MEMBER ABDEL-KHALIK: I am still trying to nail this down. The words "NPSHA conservative" that line, is this a Design Basis LOCA --

MR. LOBEL: Yes.

MEMBER ABDEL-KHALIK: -- analysis?

MR. LOBEL: Yes.

MEMBER ABDEL-KHALIK: And you are saying that this is going to be close to the 95/95 calculation that --

MR. LOBEL: We have calculated that and I will show it to you a little later.

MR. WALLIS: Yes, but the regulatory basis is the conservative analysis.

MR. LOBEL: Yes.

MR. WALLIS: So the 95/95 is not an alternative.

MR. LOBEL: Well, we made it an alternative. We said --

MR. WALLIS: This is a risk --

MR. LOBEL: -- you could either. We said you could use either.

CHAIR SHACK: In the current version of the guidance, it is an alternative. We can comment on that later.

MR. WALLIS: This morning, I was assured that it was the conservative one, which was the regulatory basis.

MR. LOBEL: The topical report says it is the conservative one because the only other choice in the topical report is the statistical. What I am talking about is the staff guidance and that is a little different.

MR. WALLIS: But when the licensee does go through all this stuff, they can submit the statistical analysis as their basis for having an acceptable NPSH.

MR. LOBEL: They could have done that.

MR. WALLIS: Would the staff accept that?

MR. LOBEL: Well we probably would have, we definitely would have thought about it a little bit more in terms of wanting a little more detail about things but yes, eventually we probably would have accepted it.

MR. WALLIS: It must be yes or no. It must be yes or no. The regulations are yes or no. They are not --

MR. DENNIG: Well these are draft guidelines.

MR. WALLIS: Oh, they are draft guidelines. Guidelines are not regulations, are they?

MR. LOBEL: No, they are not anything yet. They are being presented to you as a first draft and we discussed them with the BWR Owners' Group as a first draft and we have gotten some input from the Owners' Group that we haven't even put into these slides yet. It doesn't change anything much.

But the reason -- the conservative -- Let me try again.

The design, the licensing basis if the conservative available NPSH or the 95/95 statistical, saying they can use either and comparing that with the required effective NPSH. And the margin between that can be down to zero.

MR. WALLIS: That is what I thought it was but then this morning we seem to be --

CHAIR SHACK: That is okay. That is this afternoon so move on.

MR. LOBEL: The top part was a little different. We haven't married the two together yet.

MR. DENNIG: As Rick said, starting in 2005 with the concept of working with the Owners' Group and quantifying uncertainties in NPS. And then subsequent to that, we have had the ACRS interest. So what you are seeing is what we have developed in large part in response to ACRS input. And this meeting is another part of getting that input.

MR. LOBEL: We committed to the ACRS that we would come back and talk about the topical report. And the reason for putting it first this morning was to get some discussion of the Monte Carlo approach before we gave this presentation.

So, I wanted to go through the guidelines just in a summary from, just to give you an idea of what is coming. We are proposing this effective required NP -- I'm sorry.

MR. WALLIS: So you are doing what Harold Ray suggested this morning. You are introducing a new way of enforcing regulations.

MR. LOBEL: Yes.

MR. DENNIG: Now, this is guidance. It is not a regulation.

MR. LOBEL: Right. This is draft guidance.

MR. DENNIG: It is like a reg guide but not as formal.

MR. LOBEL: We are presenting it to the ACRS. Then if we get a favorable reaction from ACRS, then we will go to CRGR and present it to them. And if CRGR agrees, then we would start the reviews of the two power uprates that have been suspended for this issue and it would be the guidance we would use going forward for these types of reviews.

MEMBER RAY: To be clear, my concern wasn't with the precedent of the form, it was with the precedent of the content. In other words, what you call this thing isn't important. It is what it does. To me it is precedential.

MR. LOBEL: Well, I think it is. Some of what are in the guidelines hasn't changed from what we were doing before and some of it is brand new. And so some of it is things that you haven't seen before.

MR. WALLIS: When you have either/or,

though, the question is if they disagree, which one is acceptable. And suppose 95/95 is bigger than conservative, if it could possibly be.

MR. DENNIG: To get back out, how this is going to be used, this is what we are proposing is generally acceptable to the staff, as all of our guidance is. And as always, the licensee has the flexibility to propose some other way. A licensee could have come in independently and proposed this to staff as the way to do things and we might have found it acceptable. We are basically standardizing and giving people a heads' up as to what we think we need.

MR. LOBEL: Another point, too, is we presented this as a draft because we were hoping to get input from the Owners' Groups. We were hoping that the Owners' Groups would help us define the uncertainties. Some of the limits that we have, particularly a hundred hours' limit that I will get to. We were hoping that the Owners' Groups and maybe their pump vendors would help show us whether that is really necessary or not, or whether that is the right number or not. So this really is draft at this point. We are still hoping to have more interactions with the industry on this before we go any further.

MR. RULAND: Rich, let me add one thing to that matter. If we don't get numbers from the industry, it is likely we are not going to approve power uprates. We are going -- you will see for containment accident pressure credit. There are certain numbers we are going to need from pump vendors and the like. And without that data, licensees, we could, one of the things we are thinking about is just saying that submittal is incomplete and we are not going to review it. So that is under consideration.

MR. LOBEL: Okay, let me go on.

The second guideline is that maximum flow rate chosen for the NPSH analyses should be greater than the flow rate used for the core and containment cooling analyses. In other words, we are trying to be consistent or at least to make sure that the NPSH analysis is conservative and are the requirements of the pump to the containment and core cooling analyses.

Like we were just talking about, either a conservative or a 95/95 lower tolerance limit from a Monte Carlo calculation should be used in determining the available NPSH for the design basis events.

Another guideline which is a current requirement of the review is that the containment isolation shouldn't be lost due to an Appendix R Fire, the association circuits problem, or due to containment venting required by procedures. There shouldn't be a situation where an operating following procedures is told to vent the containment at a time when they are taking credit for containment accident pressure. That is kind of obvious.

Operator action to control containment pressure is acceptable if justified by human factors considerations and included in the appropriate procedures.

Operation for a limited time with the available NPSHA less than the required NPSH is acceptable if justified by testing. This was already a position in Reg Guide 1.82 but we, I think we have added considerably to tightening up that requirement to making it more of a -- to define the conditions better, make it better defined as to what would be acceptable in that case.

Licensees should have the capability to detect and take action for a containment leakage rate large enough to adversely affect containment capability to retain pressure. That is what Marty talked about this morning.

A licensee should justify that the use of containment accident pressure is necessary to because the design cannot be practicably altered.

MEMBER ARMIJO: Could you expand on that? That has bothered me a lot. Does practicably altered mean a certain amount of money or is it a real engineering challenge that can't be accomplished?

MR. LOBEL: To be honest, we haven't sat down and talked about the details. We haven't really been, we have made the, I guess you could call it generic judgment that the types of things that looked like they were necessary, new pumps, bigger heat exchangers, some kind of additional cooling capability to the water before it got into the suction, those kind of things, would have qualified as not being practical.

MEMBER ARMIJO: Why is that? I don't understand that.

MR. LOBEL: Well, in terms of --

MEMBER ARMIJO: It is expensive. I understand that.

MR. LOBEL: But what we are saying by putting this in here is now that in the past we haven't asked licensees that question. We made the judgment ourselves. What this bullet is saying is that we are going to ask the licensees that question and we are going to have to come up with guidance and criteria for that.

MEMBER RAY: So you will have some specific criteria.

MR. LOBEL: Yes, I think we have to. If it is going to be a review item, we are going to have to have --

MEMBER RAY: Because I think that any of us anyway would feel like we needed to see what you come up with, in order to know if this makes sense.

MR. LOBEL: Well, if you don't see it again in terms of the guidance, if we don't pump it back again with the guidance, you would certainly see it with the extended power uprate reviews that you do.

But there may be take-aways here that --

MEMBER RAY: It would surprise people if we then said that guidance is no good on an individual power uprate. But anyway, leave that --

MR. DENNIG: Alternatively -- excuse me, Rich -- rather than carry along that concept of design cannot be practicably altered, alternatively, using this new approach and new criteria, you either make the guidance or you don't make the guidance. And if you don't make the guidance, then it is up to you to decide what you want to do next, as far as improving the situation.

Alternatively to having this concept

needing further definition is just that position. You are not, you don't meet the guidance for margin is less than zero and you are going to have to do something about that.

MEMBER RAY: Well, excuse me. I will be brief. On that point, though, going back to the operator action credit, for example, if it is justified by human factors considerations. Well again, that is a murky kind of things, necessarily. There always will be a subjective judgment as to whether human factors considerations justify taking credit for operator action, whether it is practical under the circumstances to do that. We referred to the head-flow curves earlier. We have all seen those. We understand in principle at least what the operator is expected to do.

So again, it becomes a matter if you just took away item eight to respond to your comment and said well, full stop, you didn't meet the guidance, that is the end, go away, it would suggest, I think that everything else was sufficiently objective that we would be satisfied that the requirements were met, the guidelines had been met.

I don't know that eliminating eight, which I took to be your point, is what we are asking for.

CHAIR SHACK: It is consistent with our previous letter. What we asked for was that eight be the first priority, rather than the last.

MEMBER RAY: It just seems like it is out of order is the problem.

MR. LOBEL: No, I think putting it in here means that we are going to ask licensees isn't there anything else you can do. And we will have to develop criteria to evaluate an answer to that.

MEMBER BROWN: But you have already got it in your mind what those criteria are. I mean, you have already said if they had to replace a pump, that is too hard. If they had to replace a heat exchanger, that is too hard. And on, and on, and on.

MR. LOBEL: Well, I mean, that is what we have been doing.

MEMBER BROWN: It becomes a money issue.

MR. LOBEL: That is what we have been doing up until now.

MEMBER BROWN: Oh, it is.

MR. LOBEL: I really think -- I don't have the prejudice about what this would mean, what the new criteria would be. That is how we were thinking of it in terms of not asking the question. Now that we are going to ask the question, I think we have to come up with criteria for evaluating it.

MR. WALLIS: Rich, how about a new reactor? Does eight apply to a new reactor? They have to keep changing the design until they don't need CAP?

MR. LOBEL: Let me just say I have talked to the new reactors people. I can't speak for them but I have talked to the new reactors people and I have advised them that they would be much better off not approving use of containment accident pressure.

I can't speak for what they are going to approve but we are in contact with them. We have talked with them quite a bit actually. So they know what has been going on here.

MEMBER ARMIJO: Would turning off a containment spray be an acceptable operator reaction in these guidelines? In the event you are in a LOCA, to maintain sufficient head, you just --

MR. LOBEL: I think you would have to think about that. I mean, when you said that the first thing that came to my mind was it might be okay to turn it off but how long can you turn it off before you need to turn it on again, if you do?

It is that kind of question that would go into the review of an action like that.

MEMBER ARMIJO: Well that is the philosophy that really bothers me the most. It kind of just says that is, we never should do that. We never should disable or --

MR. LOBEL: Well BWR procedures now have a caution. If a plant is taking credit for containment accident pressure that cautions the operator, the normal action is the containment pressure can go down to zero psig. That is okay. But if you are taking credit for containment accident pressure, then there is a caution that says make sure that you have the pressure that you need. So that kind of thing is already in their procedures.

MEMBER BROWN: What if you can't turn it back or now it becomes something breaks but you have got now air in the line or something like that.

MR. LOBEL: Or the motor needs some time before you can turn the --

MEMBER BROWN: Whatever. Okay but once you are in these accident conditions, you can all of a sudden get air in the line, where you may not be able to -- it will block the flow. Whereas, it already had vented, it was ready to go and was operating. Now you turn it off, you can't turn it back on.

MR. LOBEL: And that is the kind of

question that would be asked in the review. I am not saying we would automatically say any operator action. That is the kind of question that would be asked during the review.

And we have asked that kind of question before. Licensees have, in terms of what was the issue -- there was an issue where licensees came in and they said we don't need this many pumps. Our first operator action is going to be to turn off the pump. And there are a lot of questions about, you know, are you sure you are never going to need that pump? What about if one of the pumps you are taking credit for doesn't start when it is supposed to?

All that kind of thing goes into the review. It is hard to put all that into a statement beforehand. So that is the kind of thing the staff should be asking.

MEMBER ABDEL-KHALIK: Are we doing away with GDC-38?

MR. LOBEL: No.

MEMBER ABDEL-KHALIK: So GEDC-38 says essentially that operators should rapidly reduce the containment pressure and temperature. So how does that square with what you are proposing?

MR. LOBEL: Well in a way it squares with

GDC-35 that requires abundant cooling.

The first priority is flow to the core.

MEMBER ARMIJO: If that is the only alternative you had, either ignore 35 or ignore 38 but there is another alternative and that is fix the pump and meet both criteria.

MEMBER SIEBER: Or don't bring the power uprate.

MEMBER ARMIJO: Or only run power uprate to --

MEMBER BANERJEE: There are thousands of things that you can do.

MEMBER ARMIJO: I guess I am hardware-oriented and deterministic and I said, look, you know, there is a way to fix this stuff but it is not getting enough attention.

MR. LOBEL: Well that gets into another issue, which is backfit and we have regulations for that. And we have to follow that 51.09 also.

MEMBER ARMIJO: But for a power uprate, would that be a backfit?

MR. LOBEL: No, that wouldn't be a backfit.

MEMBER BANERJEE: We are talking about upgrades, right?

MR. LOBEL: Well, there are other situations, too, but for uprate, no, that wouldn't be a 51.09 issue.

MEMBER ARMIJO: That is where my concern is.

MR. LOBEL: I think we haven't discussed that --

MR. RULAND: Rich, let me add something about this.

Essentially the implied cost benefit analyses, current Commission policy does not require licensees to do cost benefit analyses for modifications that they are proposing. The staff is required to determine if their proposal is acceptable and assures reasonable assurance of adequate protection. There is no requirement for the staff to do a cost benefit analysis.

What we are saying by number eight is we are going to require licensees to answer this question and the staff is going to make a case-by-case judgment about whether or not this is practicably altered. You have the staff in the past two reviews, I am thinking at least Browns Ferry, excuse me, Vermont Yankee, the licensee claimed it was not practicable to dig a hole under their ECCS pumps and lower them. The staff accepted that.

MEMBER RAY: Yes, but that is not the only alternative that might exist.

MR. RULAND: That is correct. Rich, go to the next. Does the next slide talk about the cooling system? Number 12. Number 12 says, and this is a modification that licensees in fact might be reasonably required to do is to protect the mechanical seals from excess entrained air.

One of the thing we discovered when we did the -- when we talked to our pump consultants was they brought out the importance of mechanical seal faces. So one of the things we have added to our guidelines is in fact that we believe that they should provide external cold-water flushing to the mechanical seal faces. In our concept of the way this works right now, we believe that as a practicable modification that licensees could make.

The history --

MEMBER RAY: Now wait a second because you just used the word practicable again but a little bit earlier you talked about reasonable. You used both of those terms. I think you mean to stick with practicable. Correct?

MR. RULAND: Yes.

MEMBER RAY: All right. Certainly what you said is practicable. Other things are practicable, too. Practicable doesn't imply cost benefit. It doesn't. Reasonable might.

CHAIR SHACK: Well, I also look at 12 as closer to adequate protection. That is, the conclusion is that you can't do this kind of operation without this system. So there really is no cost benefit here. This is what you need to do if you are going to run these pumps in that region.

MEMBER RAY: From my standpoint, I realize I interrupted and I apologize but I just wanted because you just used the word again.

Practicable is a very regulatory space that you deal with in rate regulation and so on. Practicable is a very precise term that means it can be done. And I am satisfied with your use of that term, if you use it consistently and you mean it.

MR. RULAND: I would argue at this point that the staff probably didn't use it to the precision that you are asking us to use it.

MEMBER RAY: Okay, I would ask you to use it to that precision or come up with something else that is equally understandable because practicable means exactly what the dictionary says it means, which is -- well, I will defer --

MR. RULAND: It is doable.

MEMBER RAY: That's right. It can be done.

MR. RULAND: I understand your question.

MEMBER RAY: All right.

MS. ABDULLAHI: Can I make a correction? Vermont Yankee came up a couple of times today in which you were the reviewer at the time, I suppose. I thought they made a modification so that their heat exchanger was able to cool for the LOCA. They made some plant modification. Maybe they put a service water or another heat exchanger.

MR. LOBEL: Yes, I think it was for Appendix R. They added two service water pumps. Two RHR service water pumps.

MS. ABDULLAHI: And that was their most limiting case.

MR. RULAND: Yes, I think --

MR. LOBEL: I am not sure if it was.

MR. RULAND: I think they protected a second pump is what they did. It was they wrapped the cables to protect the setting.

MR. LOBEL: If I remember right, what they did, what they used, they made that change so they didn't need containment accident pressure for the Appendix R event.

MS. ABDULLAHI: I just want to make that clarification.

MEMBER BANERJEE: I think Rick is precisely correct. The reason they did it was against Appendix R. They protected one train.

MR. WALLIS: Can I ask about number nine? I don't know what you mean by maximum erosion zone.

MR. LOBEL: I am going to explain that in as much detail as --

MR. WALLIS: I don't know where the hundred hours came from. It was just thrown up by your consultant without any justification.

CHAIR SHACK: Let's go on. We will come back to these. We are just trying to get through the guidelines.

MR. WALLIS: -- what you mean later on?

MR. LOBEL: Yes.

MEMBER ABDEL-KHALIK: This is an important point, though because the maximum erosion zone corresponds to a ratio of greater than one. Right? Both the lower bound and the upper bound.

MR. LOBEL: Yes.

MEMBER ABDEL-KHALIK: So you are allowing them, I mean, I can be outside this maximum erosion zone.

MR. LOBEL: Inside.

MEMBER ABDEL-KHALIK: I can be outside this maximum erosion zone if I operate at a ratio less than one.

MR. LOBEL: Yes.

MEMBER ABDEL-KHALIK: And would you allow them to do that?

MR. LOBEL: And there is another criterion they have to meet. They still have to show that the available is greater than the required so they can't go less than one.

MEMBER ABDEL-KHALIK: So they always have to be on the high end of this maximum erosion zone.

MR. LOBEL: Yes. They are always going to be above.

MEMBER ABDEL-KHALIK: Okay.

MR. LOBEL: This criterion is just speaking to this maximum erosion zone.

MR. WALLIS: Oh, okay. Well that makes -that creates margin.

MR. LOBEL: A realistic calculation of available NPSH would also be done to compare with the available NPSH determined from the conservative or the

95/95 Monte Carlo.

MR. WALLIS: I don't know what you mean by that again. I mean, realistic, the Monte Carlo presumably embraces the realistic somewhere. Well the 59 runs, I mean, the mean or something is realistic, isn't it?

MR. LOBEL: It turns out that for the calculations we did, the realistic and the mean are practically on the same line also.

MR. WALLIS: Have the same conservatives in them?

MR. LOBEL: No but it turns out they are about the same line. And --

MEMBER ABDEL-KHALIK: Now what would be the purpose of number ten. If you are only comparing available NPSH using different calculational methods.

MR. LOBEL: Just to give another indication of margin. Really for the ACRS more than anything just as another indication of margin. We are going to have margin between the available and the required, conservative or realistic.

We also wanted to have a comparison between conservative and realistic just to show the margin that there is in the realistic.

The question that was asked several times here was I had a slide once with like a page and a half single spaced of all these conservatisms and the calculation and the question was asked how much is any of that worth. And so one of the things we tried to do here was to answer that question. So this goes to answering that question in a way, too. We are going to show a comparison between conservative and realistic.

MR. WALLIS: I have difficulty with asking them to calculate something without them knowing what you are going to do with it. And if they say you must calculate this and it must be less than something, I understand that.

You must calculate something to show a mountain. That doesn't tell me what you are going to do with it. Are you going to say the margin looks to me okay, or looks to me not okay? What do you do with these numbers after they have submitted them?

MR. WALLIS: It is just a demonstration. But that is not a regulation. That is not a useful regulation.

MR. LOBEL: Well it is not meant to be a regulation. It is not meant to be a restriction on anything. It is only to demonstrate something. The other ones, the available being greater than the required, the maximum erosion zone, the mechanical seals --

MR. WALLIS: It is like a homework problem. If you calculate this, this, and this, then I will give you a grade.

CHAIR SHACK: Graham, one answer is we ask for it in our report. Okay? Just let that one go. You can complain to us later.

Let me ask another question. I thought nine and ten were coupled because nine says that that maximum operation is a ration of 1.1 to 1.6. So I thought that you wanted the realistic calculation to find out whether you really were in that zone of maximum erosion.

MR. LOBEL: Yes, that is another use of the realistic.

CHAIR SHACK: And again, that whole treatment I think is something we could discuss further but to my mind, it is not just margin. It really is a question of seeing where you really are with relation to that maximum erosion zone.

MR. LOBEL: Yes, I was just speaking to ten. For nine, you need the realistic calculation for that.

CHAIR SHACK: Okay and there you need a

realistic calculation that is more like the 95/95. That is, most of the time where you are really likely to be operating, the conservative answer may not be conservative from that point of view.

MR. LOBEL: Right. It gets back to the Vermont Yankee -- I hate to keep saying Vermont Yankee when they are not around. But it is the situation where you were so conservative that you really didn't know where you were anymore. And so that is why we are suggesting to use the realistic value.

MEMBER ABDEL-KHALIK: The hundred hours limit would apply to both the conservative analysis and the realistic analysis?

MR. LOBEL: No, it is just the realistic.

MEMBER ABDEL-KHALIK: Just the realistic.

MR. DENNIG: The logic, I think, we are in violent agreement is that for something where you have to get it just right between two bounds, the only appropriate way to do it is what your best information tell you about where you are going to be.

So your best information should tell you that you are not going to be in that zone for more than a hundred hours. And the hundred hours is an extrapolation of some limited experience data from the field and it is a number that we put out there. And if anybody has a better number or something that we can use to inform that better, then we certainly would consider it.

MR. LOBEL: Okay, we are going to come back to almost all this again.

MR. WALLIS: This is going to get all much more specific and understandable when you get a final draft is it? Because at the moment it seems that you answer questions which help to explain things, which aren't evident at all from what you put on the screen.

MR. LOBEL: Well, I am going to go through it all. This was just supposed to be a rough overview to show you where we were going. But certainly if we are going to get to it today.

The status, the issue now, there are 27 operating reactors that use containment accident pressure for NPSH, 19 BWRs and eight PWRs. There are two EPUs on hold pending revised guidance on the use of containment accident pressure.

MEMBER ABDEL-KHALIK: Of the 19 BWRs --

MR. LOBEL: All BWRs with Mark I containments.

MR. LOBEL: Of the 19 BWRs, how many of those have already received power uprate approval?

MR. LOBEL: I don't know that number off

the top of my head. I can name quite a few of them if you want but I don't know the number off the top of my head.

MEMBER ABDEL-KHALIK: I think it would be a good idea to know that.

CHAIR SHACK: Not now. Please continue.

MEMBER BANERJEE: Are there two EPU applications on the books right now?

MR. LOBEL: There are several that are under review.

MEMBER BANERJEE: Under review, yes.

MR. LOBEL: Yes.

MEMBER BANERJEE: Were they both Mark I's?

MR. LOBEL: Yes. All the BWRs, so far that need containment accident pressure are Mark I's.

MEMBER BANERJEE: Yes, that I realize but the ones under review are both Mark I's.

MR. LOBEL: Yes. There is at least one other BWR that is in for an EPU review that doesn't need containment accident pressure.

MR. RULAND: For the record, those aren't under review currently. Those two applications have been suspended.

MEMBER BANERJEE: Oh, okay. That is good. Thank you.

MR. LOBEL: Oh, okay, I didn't understand what you were asking.

Okay, to start the technical discussion a little, I don't know that, I guess I am running short of time. Let me skip some of the basics that we talked about. Let me mention this, slide nine, suction energy, since we do talk about it later.

Suction energy is a concept that provides a classification of the degree to which centrifugal pumps are prone to the adverse effects of cavitation and also another pump effect, suction recirculation. Suction recirculation is a low flow phenomenon that isn't directly connected to containment accident pressure. It is a condition where the flow is low enough that the flow doesn't completely fill the impeller blades and you get cavitation as well as surging. It is similar in some ways to different mechanism but in some ways it is similar in effect to a water hammer. You get large pressure surges in the system that can damage the system but it is not directly connected to containment accident pressure.

I give the definition of suction energy. It is a concept that is proposed that has some benefits over some of the previously used criteria for limitations on pump operation. It is classified as low suction energy, high suction energy, and very high suction energy.

The BWR, RHR, in-core spray pumps are either high energy or very high suction energy pumps. As the suction energy increases, the pumps become more susceptible to adverse effects. So it is a fairly accurate description of the susceptibility of the pump to problems.

I will skip net positive suction head. That was just to define some of the terms that we have been talking about today so far.

On this slide, the purpose of this slide was to try to give the first introduction to required NPSH. As the flow comes through the suction pipe, Item 1 and gets to the pump suction flange, Item 2, the pressure at the suction flange decreases as the liquid flows from the suction flange through the suction nozzle from two to three and into the impeller eye, item four.

MR. WALLIS: It looks like an orifice but it isn't, is it?

MR. LOBEL: I'm sorry. What?

MR. WALLIS: The way you have drawn it, it looks like an orifice but it not.

MR. LOBEL: It is not, no. I didn't draw

it. I don't take credit for it. It was the only reasonably simple drawing I could find and it already had the numbers on it so I used it. But no, there is no orifice there.

It has a few other problems to it. But anyway, the point is that from the suction flange to the impeller, there is a decrease in pressure and an increase in flow. And so the low-pressure point, the point at which you would expect cavitation to occur is all or near the entrance to the blade. It is usually, and it depends on the flow rate you have and the angle of incidence to the blade and all that exactly where you will get the cavitation but it is usually close to the blade leading edge and may continue for some distance up the blade.

The required NPSH is just the NPSH that is needed. The stagnation energy or the total energy that the liquid has to have in order that the pressure at the beginning of the blade would be low enough to give you a certain amount of cavitation. And that is specified in the number for the required NPSH how much cavitation you are going to allow.

The next slide just goes into a little more detail of this. The required NPSH is determined by a test. Usually this type of test where you have -

-

MR. WALLIS: At which point in this figure, one, two, three, four, five, do you measure the pressure in which you evaluate NPSH?

You would calculate the available NPSH at two.

MR. WALLIS: At two.

MR. LOBEL: And the required NPSH is to give you a certain cavitation for a drop in pressure from two to four.

So you would start at the suction source and figure all the lines losses, valves, fittings, piping, and all that until you get to two. And that would be the loss term and the elevation term and the pressure term above the water would all be the values that you would calculate at two, at location two.

The test that is done to determine the required NPSH simply is usually at a tank of water, a suction source. The pump takes suction from that tank at a given flow rate at a given pump speed and returns the water back to the tank. The tank may have a constant level or you may change the level to change the available NPSH. And what you do is you start out the test at a given flow rate and pump speed and the pump will put out a certain head, a certain discharge head, a total dynamic head it is called. And that will be horizontal. It will be constant until you get to a point where the cavitation in the pump is such that the pump just can't put out that head anymore and the head starts to drop. And the three percent head-drop, which is what the hydraulic institute recommends for the definition is simply where this curve has dropped three percent from --

MEMBER BLEY: I thought it was a three percent drop in flow, not in --

MR. LOBEL: No, it is in head.

MR. WALLIS: So you have some of the valve --

MR. LOBEL: Well what it says, I think is that for that three percent drop in head, you have to determine the corresponding flow.

MR. WALLIS: Well you have to have to have something that keeps the Q constant while this is happening.

MR. LOBEL: Yes. You adjust valves and you also, in a good test, might have a vacuum pump to control the pressure above the water and also to de-aerate the water. I am describing it very simply.

Okay, getting on to some of the new stuff.

The uncertainty in the pump vendor's test for some of the reasons I said is really on the low side because the test is carefully controlled. You are controlling the height of the water. You are controlling the temperature of the water. You are controlling maybe the air in the water, the pump speed. All those things, the suction piping is usually a straight run of pipe. So you are minimizing the uncertainty in that determination.

If you take that pump, when you take that pump and you install it in the field or at the power plant, you may not have the same kind of control over all those conditions. And so the uncertainty is going to be greater on the installed pump and thanks to our pump consultants, we have considered these effects to increase the uncertainty over the vendor uncertainty.

So we have looked at the possibility that the pump speed could change, that the water temperature could be different than the temperature that is used. Usually in a required NPSH test, the temperature is at ambient 60, around 60 degrees or so. The suction piping layout could be much different. The air content of the water could be different. The pump that is tested at the pump vendor facility will be basically a new pump and it won't have any wear. So the wear rings will have whatever the starting clearances they have won't be increasing in time.

MEMBER ARMIJO: Rich, where is that on that little sketch? Is it right at the bottom of the impeller?

MR. LOBEL: It is not really shown. It is between, it separates the discharge flow in the region of the impeller from the suction flow going into the impeller.

MEMBER ARMIJO: Okay, I just was curious where that would be.

MR. LOBEL: I have a better pump drawing that shows it. Let me see if I can work this thing.

MEMBER ARMIJO: Well when you get to it just point it out. I may be the only one --

MR. LOBEL: Well, I had it as a backup slide. Okay, let's just go on.

MEMBER ARMIJO: Yes, just keep -- when you get to it.

MR. LOBEL: Okay. So what we are proposing to do is to essentially define a new required NPSH, an effective required NPSH that would include these uncertainties. And we will use that required NPSH, the effective NPSH for NPSH margin determinations for the LOCA.

For the non-design basis events,

consistent with current staff practice, we just use the three percent head-drop NPSH, the hydraulic institute definition of NPSH. That is the proposal.

We talked about this a little already. It turns out that the maximum erosion occurs between the point of incipient cavitation and the three percent head-drop.

MR. WALLIS: When you get more cavitation you start to get less erosion?

MR. LOBEL: Yes, and I am going to explain that.

MR. WALLIS: Because they don't collapse so rapidly or something?

MR. LOBEL: You have so much more vapor. The quality is very high. There is --

MR. WALLIS: It makes a difference how much air you have because the air cushions the cavitation.

MR. LOBEL: Air also cushions the cavitation, too. That is right. It turns out that the point of maximum cavitation is between the incipient cavitation where you have the first numbers way out to the right on that curve, the test curve I was showing and the three percent head-drop.

Let me go to --

MR. WALLIS: These guys have to calculate both incipient cavitation and NPSHR three percent.

MR. LOBEL: Well, no. What I was going to say --

MR. WALLIS: To know if they are in that zone.

MR. LOBEL: Let me do the next slide. I think it will be easier.

This is a picture trying to explain what is going on in the pump with different levels of cavitation. The effects of cavitation depend on the amount of voiding you get, the amount of vapor you are forming and the distribution of the vapor in the front. This picture shows that test curve again and it also shows an edge view of two impeller veins, just to illustrate where the voids are.

Moving from left to right on the curve, at very low available NPSH values at Point D, it is called, you are in the break off region. The pump is hardly pumping anymore.

MR. WALLIS: -- is the same NPSH as C. So you don't know where you are if you just measure NPSH.

MR. LOBEL: Well, C is supposed to be, there is a little artistic license. Three is supposed to be the three percent --

MR. WALLIS: There has to be some curvature because you are at a complete cliff.

MR. LOBEL: Yes.

MR. WALLIS: You don't know where you are on a cliff.

MR. LOBEL: Yes. And that is the reason -- there are two natural limits to cavitation. The first one is A, incipient cavitation where it first starts and you get just a few bubbles. There is no effect on the pump but that is a physical thing that is happening.

The break-off is also a physical thing that is happening. The pump is just not pumping anymore. But neither of those are very useful as limits because you don't know where the incipient is and you don't want to know where the break-off is because you are in trouble if you are there.

So the limit that was chosen by the hydraulic institute is the three percent value because it is something that is relatively easy to measure and gives you a change that you can measure. But you could use a one percent head-drop. You could use a zero percent head-drop right before you started to get the head-drop there. The three percent is more of an arbitrary number.

MR. WALLIS: I see because you measure it but I don't understand how you know where B is.

MR. LOBEL: Where B is? You don't know where B is.

MR. WALLIS: But you have a guidance which says you can only operate a B if you are going to --

MR. LOBEL: Well, I am going to show you how we came up with the guidance. Let's see, we are kind of going through these things fast.

So anyway, --

MR. WALLIS: Well it is important if you are going to have something which says you use B for some purpose, you have got to know how to determine where B is.

MR. LOBEL: Well, I am going to show you how we know where B is.

MR. WALLIS: Okay.

MR. LOBEL: Point D, the impeller is running in a vapor cloud. The cavitation erosion is very limited, since the impeller is surrounded predominantly by vapor and not much in the way of vapor bubbles. So even though the pump isn't pumping anymore, the good news is the impeller is in great shape.

So then moving to point C, which is the

three percent head-drop value, you still have a lot of vapor, huge volumes of vapor exist, but you have more vapor bubbles and the collapsing of these vapor bubbles is causing some pitting and erosion of the impeller and the flow is also slightly unstable or maybe more than slightly unstable.

If we go to point B, this is a state reached where there is a lot of vapor bubbles, a lot of vapor cavities and entrained bubbles in the liquid. When the bubbles collapse after moving to a higher pressure zone at the pump, you don't have the cushioning effect of the vapor clouds as much and you get a lot more erosion and this is the maximum erosion.

So even though there is no indication on the pump curve, the pump from outward appearances seems to be working just fine but it is having the highest level of cavitation.

And then finally the incipient cavitation of point A, like I was saying, there are only a few bubbles and it is not doing any damage and the pump is working fine.

MEMBER ABDEL-KHALIK: Now at point C, do you assume that the pump characteristics remain unchanged?

MR. LOBEL: At C, yes because there is another difference between what we are talking about and the usual type of thing a pump person would talk about it. We are talking about a limited amount of time. We are only talking about the time the pump is going to be operating at this three percent head value. At a process plant, if the pump was operating at that condition, it could be operating there a year or more before somebody did maintenance on the pump. So we are not talking about a very long time that the pump is going to be in that condition. And these are very robust pumps, they are very well designed, very well made, good materials, materials that can withstand cavitation. And so the time that we are talking about the pump would be in point C. We don't expect to see any damage to the point that would affect the pump performing its safety function.

MEMBER ABDEL-KHALIK: No, I am concerned about how would you go about determining the corresponding volumetric flow rate, given the fact that you now have a two-phase mixture.

MR. LOBEL: You don't. You don't. I haven't seen anything in the pump literature where people have even tried to define things similar to quality avoid fraction or that kind of thing. But they speak in more qualitative terms.

MR. WALLIS: You have a three percent loss of head and you draw your load line and you can match it with this three percent loss of head.

MEMBER ABDEL-KHALIK: But that is why I am asking whether the characteristic curve remains unchanged because it wouldn't change.

MR. WALLIS: But it is all in this pump consultant report. He has these curves.

MR. LOBEL: Oh, the pump curve?

MR. WALLIS: Yes.

MR. LOBEL: They had flow curve?

MR. WALLIS: Yes.

MR. LOBEL: It was changed. Yes, it will change at that point, depending on what the available NPSH is, instead of being on the curve, you will start to drop vertically down.

MR. WALLIS: Three percent below. It is not completely different.

MR. LOBEL: I'm sorry. I didn't understand your question.

This is how we treated the maximum erosions. One way to measure the amount of cavitation is with acoustic measurements. People put pressure transducers or other acoustic transducers on the pump suction and they measure the noise, the cavitation noise that comes from the imploding bubbles.

And this is the relative noise that is stated in terms of cavitation, erosion rate, but it is really a measurement of cavitation noise as a function of the NPSH margin ratio, the available to the required and you can see when you are up at a high value, the noise is relatively low. As you lower the margin, as the available NPSH goes down, the noise increases until you reach a peak, then from the peak you start to decrease again. And that is due to the bubbles, the vapor bubbles and due to the air that is coming out of solution in the water.

And what we did was to just, we took this curve to a typical curve and picked a high and a low boundary to this curve that captured the peak and said that was the result of maximum erosion.

MR. WALLIS: But this occurs long before the three percent.

MR. LOBEL: Yes.

MR. WALLIS: But the three percent seems to be what you are putting into the guidance that they use.

MR. LOBEL: That is what is getting put into the guidance --

MR. WALLIS: Then the hundred hours --

MR. LOBEL: -- in comparing the available to the required. And the other criterion is that you can't stay in this zone for more than a hundred hours.

MR. WALLIS: A hundred hours applies to B.

MR. LOBEL: Yes.

MR. WALLIS: So you have another line you should show the B line on your, way back when when you show what is allowable, the -- there should be a B zone shown on there somewhere. On slide three there should be a B line, shouldn't there? The B line is somewhere in there.

MR. LOBEL: Oh, this is --

MR. WALLIS: Is the B line -- where is the B line? It is above NPSHA conservative or where is it?

MR. LOBEL: Where would it be? It would probably be --

CHAIR SHACK: It could be anywhere.

MR. LOBEL: Yes, this was for a different purpose. It would probably be above the effective somewhere below that. Somewhere in the margin, what we are calling margin, I guess.

MR. WALLIS: It is a fraction of 1.5 on the NPSH, isn't it? Looking at this figure which is up on the screen now, 1.4 and 1.5. That is quite a big change, isn't it, in NPSH?

MR. LOBEL: Yes.

MR. WALLIS: Well you should show a B line on this figure then.

MR. LOBEL: Off-hand, I am not sure where I would put it on here. I don't even know where to put it on --

MR. WALLIS: It can't be the requirement for a hundred hours. You have to be able to put it on the figure and see how long the time is.

MR. LOBEL: Well, let me go on. You will see how we use this. Look at the next slide, 19. This is a calculation of a large-break loss of coolant accident. It is a plot of the available over the required NPSH, the NPSH margin ratio as a function of time. And what we did was plot the zone of maximum erosion and it is in green, it is filled in in green. And we did calculations for the statistical and the conservative and the realistic cases for the ratio as a function of time for this large break LOCA.

And we are saying that the time that you are in this green zone shouldn't be more than a hundred hours. And that is how we would use this maximum erosion zone limit.

MEMBER ARMIJO: In some of the material that the staff or someone that has gotten to us, the impeller materials make a big difference, whether it is cast iron or chrome, steel, or bronze. I have even seen some stuff on bronze that is supposed to be really good.

Now in the case of the BWR pumps, are they all using the very best material for those impellers? Or would you make any difference on your guideline?

MR. LOBEL: It wouldn't make any difference on the guideline. Well, certainly if they were using something really bad, it would make a difference. It would make a lot of difference.

MEMBER ARMIJO: So this guideline is for the very best material for the impeller?

MR. LOBEL: I don't know if you say the very best but the very good.

MEMBER ARMIJO: Best available in the industry.

MR. LOBEL: Very good, considering the pumps were built in the '60s, too. There may be better materials that might be used now. But it is very good material. We have talked with pump vendors about this and our pump consultants about this.

The material isn't a concern for the times that we are talking about.

MEMBER ABDEL-KHALIK: Now the hundred hour limit, does that only apply to the realistic input results?

MR. LOBEL: Yes.

MEMBER ABDEL-KHALIK: Okay. So in this case, it is of no consequence.

MR. LOBEL: Right.

MR. WALLIS: Why should you only apply it to realistic?

MR. LOBEL: Well the reason we are saying is because we want to know what is really happening. If we used --

MR. WALLIS: You never know what is really happening. There is uncertainty in the statistics. You never know what is really happening.

MR. LOBEL: It is --

MR. DENNIG: With a two-sided zone, there is no way to bias it conservatively one way or the other so the strategy is to get it as best you can or as best you know is the criteria. What is my best knowledge about where I am actually going to be for what you might consider a secondary criterion that goes with a more primary.

MR. WALLIS: But safety isn't based on the mean. It is based on being reasonably sure that probably nothing will go wrong. So you go for something like 95/95 don't you?

MR. LOBEL: Well, if you go for 95/95, you could even end up below here. It is a judgment.

MR. WALLIS: Isn't the statistical minimum the 95/95?

MR. DENNIG: For the NPSHA, NPSHR margin, we can bias that so that we have got worst-worst and we know what we have got. But to have this secondary criterion, we don't have a worst-worst. So again, the intention is that we need to have our, what is our best guess, if you will, or estimation of where we are going to operate or where we will be during this accident. And let's just demonstrate that you don't go in there with our best information for more than a hundred hours.

MEMBER ABDEL-KHALIK: Now let me just ask one question. The denominator in the ordinate here, NPSHR, is that the same for all graphs?

MR. LOBEL: No.

MEMBER ABDEL-KHALIK: Is NPSHR effective?

MR. LOBEL: For the conservative, it is the effective required. For the other cases, it is the three percent head drop.

MR. WALLIS: So in this case, it is the effective.

MEMBER ABDEL-KHALIK: So it is for a different mechanism that you add that.

CHAIR SHACK: No, I think in this case, it is the three percent. The effective would require you to be at some higher value instead of one.

MR. LOBEL: The effective, for the conservative we are dividing by a higher number. So if we went to the three percent, the conservative curve might move up out of the zone.

MR. WALLIS: So the NPSHR, which is shown on the vertical axis there is the conservative.

MEMBER ABDEL-KHALIK: Only for one graph.

MR. LOBEL: Only for the conservative.

MR. WALLIS: That is the same thing as NPSHR effective on slide three.

MR. LOBEL: It is the same value but for the statistical cases and the realistic cases, we use the realistic. We use the three percent required NPSH.

MR. WALLIS: Well here again, you have got to be damn sure that when you write this up formally, it is not equivocal.

MR. LOBEL: Yes.

MR. WALLIS: When you just have an NPSHR without saying which one it is, --

MR. LOBEL: Well that is why we didn't say -- yes, I know. It could have been clearer. That is why we didn't say which one it is because it is different for each --

MR. WALLIS: So they would be better off to operate as one. You are better off to have more cavitation all the time.

MR. LOBEL: But again, this is one criterion and then there is the other criterion.

MR. WALLIS: But they meet the other criterion, too.

MR. LOBEL: They would meet it as one, yes, if you could be at one.

MR. WALLIS: So you are allowed to get through the green zone and down below to one, then come back into the green zone again?

MR. LOBEL: I guess you could do that, yes.

MR. WALLIS: And then you have a hundred hours in the green zone only. You are better off to slide down lower and then come back up again.

MR. LOBEL: Yes.

MR. WALLIS: Is that real? It is that a

good --

MR. LOBEL: Wait, just a second.

Well, in terms of doing damage to the impeller, yes, because at the three percent, you are not doing that much damage to the impeller. It is at the higher value.

CHAIR SHACK: If you look at this logically, the one to pick would be the statistical minimum because again, we are not worried just about uncertainties in the calculation. We have a whole batch of scenarios that we have to look at. The statistical minimum is the one that in fact looks at all the scenarios. And if you keep the statistical minimum above 1.6, then that is your only guarantee.

Once you sort of pick any other thing, you know, you don't know what scenario you are going to be in. You could be in there, the other one is whether the hundred hours is so conservative that maybe you don't need to worry about it. And you know, but it if you are providing assurance, I don't see how you can pick much of anything except the statistical minimum and put the criteria on that.

MR. LOBEL: Well, what we were trying to do is leave the choices to the realistic or the conservative because we are not asking licensees to do a Monte Carlo calculation. That is a very --

CHAIR SHACK: But as you described your realistic input, that really only covers one scenario, the summer day. And if I get my break in January, I could be down in the zone of maximum erosion, unless I know where my statistical minimum is. At least 95 percent of the time, I know I am out of there.

MR. WALLIS: I have a concern about the numbers.

CHAIR SHACK: You know, if you don't like 95/95, pick another one but I would think you would want to keep most of your scenarios -- unless you can convince yourself that the hundred hours is extremely conservative, in which case you don't have to worry perhaps where you are in the zone of maximum. You can avoid the erosion by either making the time very short or staying above it but somehow allowing yourself to float around, I don't understand it.

MR. LOBEL: Well, we think the hundred hours is conservative. We don't think there is any possibility that the impeller will have enough erosion that it is going to affect the safety pump function in a hundred hours.

MEMBER ARMIJO: What does your pump consultants, your expert consultants say about expected life in that green band?

MR. BUDRIS: My name is Allen Budris. I am a pump consultant for NRC, over 40 years' experience working in the pump industry for the likes of Goulds and Worthington and that sort of thing. I was director of product development for quite a long time for them. The last eight years, I have been a consultant.

And one of my areas of specialty throughout my career has been cavitation and that sort of thing. And I spent, I don't know, like 25 years working with the Hydraulic Institute on some of these standards. I was the chairman of the work group on the NPSH margin standard that was developed and also on the pump piping standard before I left the Hydraulic Institute.

And so anyway, so you are asking about this hundred hours. I mean, there are so many variables, I mean, not to mention air, you know, a little bit of air can reduce the damage and that sort of thing too substantially and all these various variables.

But the few things I have looked at when I first got involved in this, there were some Sulzer reports where they had actually done some tests of these types of pumps in their field and, you know, they ran them maybe for a day and saw absolutely no damage running around a three percent or less than a three percent value.

I have personally seen cases where there was substantial damage even with even stainless steel, which is a fairly cavitation corrosion-resistant material and that happened after like two thousand hours or something like that.

CHAIR SHACK: Well your report sort of focused on the very high suction pumps, which happen to be the ones that are of interest to us.

MR. BUDRIS: Yes, very high suction energy?

CHAIR SHACK: Yes.

MR. BUDRIS: Yes, suction energy, right.

CHAIR SHACK: Those seem more susceptible.

MR. BUDRIS: Right and the one I was referring to actually wasn't nuclear power. It happened to be a cooling pump but some of the worst cavitation damage happens water around 100 degrees or something.

CHAIR SHACK: Well the other things I wondered was your hundred hours an estimate at the three percent NPSH or at the maximum erosion rate?

MR. BUDRIS: That was at the maximum erosion rate.

CHAIR SHACK: Okay. So that is a maximum erosion rate.

MR. BUDRIS: And I will agree that the Sulzer tests were probably mostly done in around 1.0, around the three percent intra point.

MEMBER ARMIJO: And this experience is for stainless steel impellers.

MR. BUDRIS: Yes, at least the one I had for like two thousand hours. That was substantial damage where they had to replace the impeller. Because I mean, you can get a little bit of damage because cavitation is time-related. And you get a few pock marks in an impeller and it is still mostly going to do this performance you probably can't even pick up any real reduction in performance. So you have to almost have the erosion go all the way through and break off pieces of vein, before you really substantially impact the performance of a pump.

MEMBER ABDEL-KHALIK: On this graph, these various methods or the various results that you present take into account uncertainties in the calculation of NPSH available.

MR. LOBEL: Yes.

MEMBER ABDEL-KHALIK: Okay. Your proposal to --

MR. LOBEL: To the degree by their definitions, the realistic not so much, the conservative. Their conservative but you don't know what the margin is.

MEMBER ABDEL-KHALIK: My question is, why don't you have the same denominator in this plot, which is the NPSH-effective, required effective for all the calculations, since the uncertainties in the required NPSH would be the same, regardless of how you calculate the available NPSH.

MR. LOBEL: We could have done it that way. We chose to, since it was realistic, to use the three percent value. But we could have done it that way. We spent a lot of time talking about --

MEMBER ABDEL-KHALIK: But I mean, you are doing a realistic calculation to account for uncertainties.

MR. LOBEL: Yes.

MEMBER ABDEL-KHALIK: And here, you have decided to essentially forego any concern about uncertainties in the required NPSH value.

MR. LOBEL: It would be easy to do it that way. It would be the same containment calculation and just a different number in a spread sheet.

MEMBER ABDEL-KHALIK: But if you were to do that, then these realistic graphs would fall lower than where they are on this plot, depending on how much difference is there between -- right?

MR. LOBEL: Yes.

MEMBER ARMIJO: Would the statistical minimum go into the green zone then?

MR. BUDRIS: I think this would stay the same except that you would say on your NPSH over NPSHR, the NPSHR would be really the effective. But as long as it is effective, as long as it is really what the pump is seeing, then this is still valid, the 1.2 to the --

MEMBER ABDEL-KHALIK: I understand but if you take the numbers that he has calculated and re-plot them, except for the green curve, all the other curves will go down because you are dividing by a larger number.

MR. BUDRIS: Okay, yes.

MR. WALLIS: I am pretty concerned applying these figures, these numbers, I mean you have got a 1.21 margin and then you have got a 1.6 factor. So your 22 feet is going to become 39 feet by the time you got those two factors. I wasn't aware that we were changing these NPSH requirement by such a huge amount.

MR. LOBEL: We're not. You mean, as a limit?

MR. WALLIS: If you take this 1.6 factor on top of the 1.21 factor --

MR. DENNIG: Rich? The uncertainties in required or plus or minus things. Right? They are plus or minus. So about the NPSH are three percent. The adjustments are for measurement or for field, they are plus or minus things.

MR. LOBEL: Yes but you apply them as a plus.

MR. DENNIG: Right. But then for purposes of what is your best information about what the actual NPSHR is, you know, what should you use, a number that has got uncertainty added to it, a number that has got uncertainty subtracted from it, or something that it is in the middle for this purpose.

MR. LOBEL: I'm not sure they are all -- Are they all plus or minus?

MR. BUDRIS: Well they are not all plus or minus. Like wear would be the only negative. But I mean, there is some. Speed, conceivably could be a plus or minus. So some plus or minus. Temperature, as a matter of fact, is a minus. That actually helps you. So you throw in water temperature.

MR. WALLIS: All of these are pluses here. Aren't they? I mean the 1.6 factor is a plus.

MR. LOBEL: The factors put on already are 1.21.

MR. WALLIS: So what are you going to accept here? The statistical minimum can go into the green zone for a while and come out again. It can go all the way down to one and come back out again, as I said before. Is that acceptable?

MR. LOBEL: Yes. It is the total time of maximum erosion.

CHAIR SHACK: But again, the question whether you should be using the realistic value, you know, in my mind, it would seem to be that the statistical minimum should not be in the green zone for more than a hundred hours.

MR. WALLIS: No but they can tweak their pencil. They can make things more conservative or something and move it down out of the green zone so they can get below.

CHAIR SHACK: That is not a good sign.

CHAIR SHACK: No, no. Because you are going to have to keep the conservative one above one.

MR. WALLIS: But still, you have got to do that. But you can make a more conservative assumption and make your plot look better because it comes down below the green and then it comes back again. It doesn't seem to be right.

MR. DENNIG: My impression is that we agree with the chairman of the subcommittee, that we should seriously consider the statistical minimum as what we should be using here.

CHAIR SHACK: For your wear rate, kind of --

MR. DENNIG: Yes, for this in the zone thing.

MEMBER ABDEL-KHALIK: Provided you divide by NPSHR effective to account for uncertainty in the required NPSH value, R-value.

MR. DENNIG: I think we will have to think about that. I understand your point. I just am not convinced that there is an uncertainty that is just in the one direction.

MR. BUDRIS: Probably the NPSH required could be like the other where you would have a minimum, a mean, and a maximum uncertainty. You know, there might be a realistic uncertainty which isn't quite as much as you might put in for the maximum.

MR. WALLIS: Well the problem is if it is better to be lower, then I am not sure 95/95 makes sense anymore. It is better to be lower if you got out of the green zone. You are no longer bounding things.

CHAIR SHACK: The thing with the statistics issue, you are supposed to try to be realistic. You are not supposed to come in and --

MR. WALLIS: That's right. I understand that but then you said the worst case is my 95 percent, 95/95 extreme. But in here, it is bound to be more extreme we get down to one.

MEMBER ABDEL-KHALIK: A more realistic plot of this would show the green curve below the zone and the red curve within the green zone lasting less than a hundred hours.

MEMBER ABDEL-KHALIK: Well, no. This might be a realistic --

CHAIR SHACK: But the question, it seems to me that if the conservative calculation is good, to see if you can pump, if you have enough. And again, to protect yourself against erosion, it really seems to me that you need to look at all the possible scenarios which is the statistical minimum.

MR. RULAND: Just one point about this

limit, we believe because this was a phenomenon we felt we needed to address, we devised this hundred hour limit that is really an order of magnitude less than typically is found for pump failures. So we are talking typically for erosion failures on the orders of a thousand or thousands of hours.

CHAIR SHACK: Yes, but we are talking about very high suction energy pumps here operating at the peak erosion rate.

MR. RULAND: I understand. And even for those suction energy pumps, we are talking a thousand or thousands of hours for erosion.

CHAIR SHACK: I thought there was a lower number in Mr. Budris' report.

MR. RULAND: And because of that, we still felt we needed to have a limit. And that is why we devised this limit as we did. However, in spite of that caveat, the staff is going to go back and re-look at this limit to decide precisely whether we should use the statistical mean or not. And so the staff will get back to you on that.

MR. LOBEL: The idea, too, was that doing a Monte Carlo calculation is a very intense thing to do. It takes a lot of effort to do that and we were trying to come up with something that would do the job without having to do the Monte Carlo calculation.

The other thing is maybe the owner wants to speak to this is one of the reasons the topical report is not part of the licensing basis because it put a burden on them in terms of Appendix B keeping up the data, making sure that the data stayed valid, if a calculation was a licensing basis calculation.

So we were trying to avoid. We showed it here. We did this ourselves but we were trying to avoid making the Monte Carlo calculation a requirement.

CHAIR SHACK: Well it would seem to me then that you really need a much better database to justify the hundred hours. You know, to make sure that in fact there is a large factor of safety on that.

MR. LOBEL: Well in fact, I was really hoping for that. I was really hoping that one we put out our draft guidance, one of the reasons it is draft guidance is that we would get some information that would tell us whether a hundred hours was okay, whether we needed a limit at all. I mean, somebody came in and said, look I run these pumps in this zone forever and have never had a problem, then we can drop this criteria. We haven't gotten there.

MR. WALLIS: We have got two criteria now. One is that the minimum has got to be above one. The other one that you have got to be within this zone for not more than a hundred hours.

If you do your 59 runs, you look at them and you say well, we are okay because you know, the worst one is above one in that criterion. But there may be three of those runs which are in the green zone. So what is statistically okay for one criterion isn't statistically okay for the other criterion. And I think you have got to think this through whether you want to be in that kind of a bind.

There may be ones which are fine. Do you see what I am getting at? There are some intermediate runs. We have spent more time in the green zone because it is at the higher level of NPSH.

MR. DENNIG: Yes, we are going to go think about this.

MR. WALLIS: You have to go think about it.

CHAIR SHACK: That is why you put the 95/95 above the green zone.

MR. WALLIS: It if is always above the green zone, that is okay. That is a new criterion.

CHAIR SHACK: That is a new criterion.

MR. WALLIS: Then the hundred hours is irrelevant if it is always above there.

CHAIR SHACK: No, it can dip into the green zone for a hundred hours.

MR. WALLIS: But it can't go below and come back up again?

CHAIR SHACK: Total hours in the green zone, as I would understand it would be --

MR. WALLIS: Then you get into my problem. You have got two criteria.

MR. LOBEL: It could but if you look at the shape of the curves, they don't seem to do that. They may seem just to go down and level off.

MR. WALLIS: Think about it anyway.

CHAIR SHACK: Onward.

MR. LOBEL: And again, these calculations are all for one type of plant.

Okay, another criterion that was an existing criterion was that the staff was allowing in some previous reviews that the available NPSH could be below the required NPSH, if the licensee performed a test and showed that pump could go for that length of time and when the pump was inspected after the test, there wasn't any sign of damage or wear to the pump. We thought about that some. We got advice from Mr.

Budris and added some extra requirements to that, guidelines to that. An important one, I think, was to make sure that when the pump was tested, it was tested at the available NPSH value that was expected. That hadn't been part of our review before and if you think about what we have been saying if the pump experiences the most cavitation in this area of 1.2 to 1.6, if you are testing the pump farther and farther to the left, you are getting farther and farther away from the area of maximum erosion. So maybe the tests that have been done up until now haven't been the right tests. Maybe they should have been whatever the times is in the area of maximum erosion or at least in an area where it is predicted the pump is going to operate, not at some value where you have so much vapor that you don't have any bubbles anymore and you are not going to get cavitation damage. So that is something that we thought about some more and probably still need some more thought.

Protection of the mechanical seals, we talked about the --

MR. WALLIS: That the best regulation is the simpler one?

MR. LOBEL: Definitely. And actually, that is a lead-in to this next one. Whoops, I am not keeping up with myself.

That is an important point for this one, too, that if you are going to take credit for accident pressure, the way that is done, I don't know that it is clear to everybody, is what you do is you do a calculation assuming no accident pressure. And you see what the available NPSH is and if you are okay, if you have enough margin. If you don't have enough margin, if the available is below the required, then you add pressure to get up to the point where the available is equal to the required. And that is the containment accident pressure that you are crediting.

So if you are doing that, you are making the available equal to the required so the pump is going to, according to the calculations, is going to be operating at that point. And at that point, you could be releasing air. The air that is dissolved in the water, which at 190 degrees isn't much, but you would still be releasing that. And that air would tend to go towards the mechanical seals, towards the shaft and the mechanical seals just be centrifugal force throwing the liquid out.

And so the concern is that the seal faces may run dry and if they do that, they are not going to do that for very long before they experience damage.

So this criterion says protect the seals by having an external source of cooling so that they won't run dry.

Implementing something like this makes things more complicated also. You are adding a system to the pump that the pump is going to need to operate properly. So, it has its drawbacks also.

And so this is another one where we have to evaluate whether this is really necessary with experience. Do pumps really see this kind of effect? And is the solution we are proposing really the right solution? And for this one too we would like to get more feedback from the pump vendors and the Owners' Groups and have more discussion with our own pump consultant.

CHAIR SHACK: How close do you have to be to the three percent NPSHR before this becomes a concern?

MR. LOBEL: Allen, do you want to answer that?

MR. BUDRIS: Well it depends on how much entrained air you really have. The one thing I have seen from tests I have performed is that and that is the reason for this peak and then why it drops down. I have measured actually the entrained air in the water as it went through the NPSH test, which meant we were dropping because NPSH available.

And you know, as you get into this point of I guess it is about 1.3, 1.4 or whatever, you know, you are picking up getting air out of solution. You know, I think what happens in part is when cavitation bubbles form, they liberate any dissolved air which now becomes entrained air, so you are adding to the entrained air. And then so the more bubbles you get, the further down you go, the more it is entrained air and that, you know, it also cushions it. But that does generate more and more air that then could then end up at the seal faces and then cause failure.

I had seen a case like that but it was really different with the vertical turbine pumps, where the pump was in severe cavitation. And that air that was liberated ended up causing some internal bearings to run dry and the pump to fail. So and the bearings were about the same place where a mechanical seal would be and pumps and such.

CHAIR SHACK: It sounds like you need a pink zone.

(Laughter.)

CHAIR SHACK: If the statistical minimum is in the pink zone, then you have to put in, install your seals, if it is above the pink zone, you don't have to put in your seals.

MR. BUDRIS: I had mentioned, too, you may not absolutely need a double seal with external cooling but as long as you have like a flush line off the discharge and maybe a throttle bushing or something like that, then as long as you preclude the air from getting to the seal. So if you have a flush line off the discharge, then you are causing the flow to go in towards the pump, which should keep the air out.

So there are ways to do it, potentially, other than just a dual-seal arrangement. They may even have now, I don't know.

MR. WOJCHOUSKI: We have that arrangement.

MEMBER ABDEL-KHALIK: Well, back to the issue raised by Graham regarding the need for sort of simpler way to define an acceptable boundary, wouldn't this issue be a lot simpler if we just simply require that this ratio always be above the zone of maximum erosion?

MEMBER ARMIJO: Yes, 1.6.

MR. LOBEL: That would be simpler, yes.

MEMBER ABDEL-KHALIK: Would it essentially address most of the issues that have been raised?

MR. WALLIS: I think this might bring some of the plants which don't need CAP into a situation where they do need CAP. Because you would have to apply this analysis, presumably, back to the cases where they have not requested CAP and now apply it even if it atmospheric pressure in there.

MR. LOBEL: It appears from these curves that we have calculated that it may be almost the same thing because the curves seem to go down a certain ways and then flatten out. So at a hundred hours, the curve is still in that zone. So it wouldn't make any difference if you had a limit on the amount of time or you didn't because you are going to exceed the limit anyway.

MEMBER ABDEL-KHALIK: But it would make enforcement of that requirement a lot easier.

MR. LOBEL: It would make it easier. We were just trying to make it more realistic but still to give the opportunity to -- The hundred hours came before we did these calculations. We didn't know what was going to happen until we had already picked the hundred hour value. We didn't know that the curves were going to go down and then flatten out.

Maybe what you are suggesting, like I am saying, it is almost the same thing. So that would be easier.

MR. WALLIS: Could you remind me? What do the plants do now who don't have CAP? Do they apply factors like 1.21 and 1.6? They don't. So they might get themselves in to the green zone if they didn't.

MR. LOBEL: Yes and when we got a little farther along with this guidance, that is a question that we have been talking about informally, just discussing among ourselves but we haven't reached any conclusion. Now those plants, that would be a backfit to impose that requirement and we would have to see whether we could justify that requirement and that would depend on what kind of backfit it was determined to be, whether it was going to be a compliance backfit or an increase in safety backfit and we haven't discussed this at all really with our management or with our lawyers. So what I am saying is in the outer edge of where we are in discussing this.

MR. DENNIG: The zone of maximum erosion was something that came up in the course of doing this analysis and it wasn't something that we expected.

Clearly, I think from your feedback, we have to go back and revisit how we would implement guidance about that particular aspect of operation. And we will do that.

MR. LOBEL: Like I said, too, another

option would be to find data that shows that these pumps can operate in that range for some long length of time, longer than we are talking about needing accident pressure and that it is not necessary.

MEMBER ABDEL-KHALIK: But that is plant-specific.

MR. LOBEL: Well probably it would be -- well, it depends how you did it. If you are going to do it with these curves, it would be plant specific. If you were just going to say that maximum cavitation, operationally maximum erosion zone even for a thousand hours isn't going to effect a pump with a certain impeller material or something that maybe that would solve the problem.

MR. BUDRIS: Can I just mention something else, too? I mentioned about this air. You know, the air which can hurt the mechanical seal and can actually increase slightly NPSH requirement, also cushions the damage, any damage you are going to get form the cavitation bubbles to the pump.

So somewhere when you get like one percent or higher air, you can substantially reduce the damage and stuff. So these pumps may actually, you know, be in better shape, plus the fact that you run quite a bit higher temperatures. The bubbles aren't as big at higher temperatures as they are when you start out at lower temperatures. So the implosion is not as much energy so you don't do as much damage. So you have two things going for you. You are running at a high temperature and if you have one percent or more air in there, you have some cushioning effect. So if that is the case, you may find out actually in the field, even though there may be in this zone of maximum erosion some of these other factors are mitigating that much damage.

So if we had any real world in the nuclear power plants, that would go a long way, I think.

MR. LOBEL: Let me point one other thing out.

CHAIR SHACK: Rich, hold up here for a second. Many of us are tending to head off for a ceremony here. So I would like to essentially recess until 4:00.

MR. LOBEL: Can I just make one fast point about this?

CHAIR SHACK: Sure.

MR. LOBEL: It is just that we are just talking about LOCA. We haven't talked about the other events yet and the curves may look different for those other events.

MR. WALLIS: This event won't take an hour and a quarter though, will it? We will probably be back here whenever the event is over?

CHAIR SHACK: That is fine with me. But I just don't know.

MR. WALLIS: Whereas we may run very late tonight.

CHAIR SHACK: No we won't run very late tonight.

MEMBER BANERJEE: Jack has a plane to catch. Are we off the record?

CHAIR SHACK: Let's come back at 3:40.

(Whereas, the foregoing matter went off the record at 2:46 p.m. and went back on the record at 3:39 p.m.)

CHAIR SHACK: Okay, if we can come back into session. As you were saying?

MR. LOBEL: As I was saying, I skipped quite a few slides because I was going to go through some of the things we have already talked about, the different kinds of calculations, conservative, realistic, and Monte Carlo, and all that, and just go to sensitivity studies.

One of the things the committee has asked for several times, I'm sorry, slide 35, was sensitivity studies, how important were the different parameters. And before this, I could only answer in terms of different markers that I have gotten from licensee submittals from different reactors. So what we did was we put one typical BWR/4 with the Mark I containment, listed all the variables that we thought contributed to the calculation significantly and then did a sensitivity study by taking the base value and varying it by five percent.

MR. WALLIS: You varied temperature by five percent. You varied the Kelvin temperature by five percent or what?

MR. LOBEL: No, just Fahrenheit. I collect thermodynamics.

MR. WALLIS: So you vary the Fahrenheit temperature by five percent?

MR. LOBEL: Yes.

MR. WALLIS: So if the temperature is 80 degrees, you vary it only by a small amount of four degrees?

MR. LOBEL: Yes.

MEMBER SIEBER: It is better than using the absolute value.

MR. LOBEL: We used conservative inputs except that we started with 100 percent power instead of 102 percent power.

And I didn't expect to go through all of these now. Maybe just make some observations. One of the observations is that quite a few of the parameters seem sensitive. Oh by the way, these are ranked in decreasing order so that the top one is the most significant. The ones that are shaded were changes of more than the five percent when we changed numbers.

MR. WALLIS: This percent is a bit misleading because you know the power pretty accurately. The surface water, the temperature actually varies a lot more than four degrees. So it is sensitivity but it is not --

MR. LOBEL: We just wanted to use the same number for each.

CHAIR SHACK: I think he is looking if he changes one thing by five percent and something changes by four percent, that is one thing. If it changes by 0.16 percent, it is another.

MR. WALLIS: I understand that, yes. But then you get into which of the variables is most important. And over its range of variation you get a different picture.

MR. LOBEL: Well some of them we did that. Containment leakage we varied by a large amount. The heat sinks we did an absence and present for the heat sinks down in the shaded numbers and heat transfer coefficients we also did that. In GOTHIC, there is quite an array of heat transfer coefficients you can pick. And Ahsan did one case with empirical correlations. In another case, there was more physical with heat mass transfer analogy. Heat transfer coefficients just to see what the difference would be.

And decay heat, we did no sigma and a two sigma to see what that difference was.

MR. WALLIS: So what did you conclude?

MR. LOBEL: Well I guess one observation was that there are quite a few variables that are in the same significance range that seem to be significant for this calculation. The containment leakage didn't appear to be too significant. The decay heat two sigma to zero sigma was certainly significant.

MR. WALLIS: But varying the containment leakage again by five percent, it is a very small change.

MR. LOBEL: Well we varied it by five percent in the white area and then we varied it by a factor of five hundred or a ratio of five.

MR. WALLIS: That is a more realistic one, yes.

MR. LOBEL: About 5.0. Strainer and piping losses weren't very significant. And the presence or absence of heat sinks was significant, as you would expect. The area wasn't too significant but the sensitivity to the condensation heat transfer coefficient was significant.

CHAIR SHACK: Strainer and piping seems strange. I would have thought that went right to the bottom line.

MR. LOBEL: It is just that it wasn't a very high number. The strainer losses weren't very large for this case, for this plant.

CHAIR SHACK: But I would have expected a five percent change to make a five percent change in the available head.

MR. LOBEL: Well part of it is, I believe if it is combined with the piping friction number two. So you are not looking just at the strainer loss.

MEMBER ABDEL-KHALIK: But this all sort of the order is an artifact of that five percent variability that you have imposed because you know, five percent change in power is a huge change; whereas a five percent in the heat sink temperature in degrees

F, because that is units dependent, is relatively small compared to the range that you expect to operate within.

MR. LOBEL: Yes. We can -- if you have any suggestions, other things you would like to see, it is not hard to re-do these.

MR. WALLIS: Well how does change in NPSH compare with the margin you have in NPSH?

MR. LOBEL: Well we weren't trying to do that for these calculations. I guess we would have to pick a required NPSH and do the calculation. We could do that, too. We weren't trying to do that kind of comparison with this.

MR. WALLIS: That is why percent change in NPSH is a strange variable. If you have a bigger NPSH, then you have a bigger change. Because how much does it change in terms of what you need?

MR. LOBEL: Well these things aren't going to change the required NPSH because we are not giving any credit for the effect of temperature on the required NPSH so any change in suppression pool temperature isn't going to change the required NPSH. I guess the pump flows would change the required NPSH a little.

MR. SALLMAN: These are the maximum values of the NPSH change. It is a transient -- during the transient -- We pick the maximum value during the transient. So very small numbers, you know, based on the calculation but these are the maximum.

MR. LOBEL: Go on?

MEMBER ABDEL-KHALIK: Yes, the change is time dependent.

MR. LOBEL: The next slide gets to a lot of the heart of a lot of what we have been talking about. This is a plot of NPSH versus time for a large-break LOCA for the RHR pumps. And this one curve has a lot of information in it for the different calculations that we have done. It has the three percent required NPSH horizontal line and the effective required NPSH horizontal line.

We used an uncertainty of 21 percent. And what we did to get that was take estimates that were in the Task 2 Report from Mr. Budris here and we added the maximum number that he gave us and didn't include the temperature correction, which was a negative number. So this is a fairly high estimate of the effective required NPSH or the uncertainty in the three percent NPSH.

It doesn't include the wear ring number. That came later and wasn't included in the calculation. So, just as an example, it is not supposed to be any one plan or any problem but just an example of the relative importance of these things.

And you can see that the Monte Carlo minimum, which is the 95/95 is very close or overlaps with the conservative available NPSH.

MR. WALLIS: This morning we were shown a very different conclusion that the --

MR. LOBEL: That wasn't for NPSH available, I don't think. I think that was for temperature, the curve we were shown.

MR. WALLIS: But it showed a very big difference between 95/95 and the conservative.

MR. LOBEL: Was that your presentation? GE's presentation. I think that was temperature, if I remember right.

MR. WALLIS: I think he showed the --

MR. LOBEL: It isn't going to overlap for temperature. Let me see if I can find our calculation.

MEMBER ABDEL-KHALIK: It was temperature and pressure.

MR. WALLIS: And pressure. Pressure was a bigger factor. Pressure were those two black curves with black squares and black triangles. And they showed a big effect.

MR. LOBEL: Okay, here is our temperature, our full temperature calculation and it doesn't have the different curves. Remember which is which?

MR. SALLMAN: Well the first one is, the top one is the conservative. The second one from the top is the maximum temperature. Then the third one, the pink color is the realistic. The fourth one is kind of black color it is mean of the statistical. And the blue one is the minimum statistical.

MR. WALLIS: Well on this curve, it is good that the statistical is above everything else. On slide 37, it is a bit strange to me that the Monte Carlo minimum actually crosses the conservative. You wouldn't expect that to happen.

MR. LOBEL: Yes, I thought that was interesting, too. I would have thought the conservative would have been below.

MR. WALLIS: It is really not as conservative as it might be, somehow.

MR. LOBEL: We will include this and give a curve with labels on it.

MEMBER ARMIJO: Is this for a real plant?

MR. LOBEL: More or less.

MEMBER ARMIJO: More or less, okay.

CHAIR SHACK: Now if I put the 1.2 and 1.6 band on here, the conservative sort of sits in it for most of the time.

MR. LOBEL: On here?

MR. WALLIS: Yes, you have got 39 for 1.6.

CHAIR SHACK: Well, I put the 1.6 on the adjusted, the effective. So I got 42.

MEMBER ARMIJO: So you can put a band on there.

CHAIR SHACK: I can put a green band on it and it sits on the green band.

MR. LOBEL: The other interesting things is that the realistic and the Monte Carlo mean coincide pretty much. And I don't know how much of a conclusion you can draw from that because this is only one calculation.

MEMBER ARMIJO: Is that a general finding?

MR. LOBEL: For other BWR Mark I's it might be pretty close but you can't say that unless you do more calculations.

MR. WALLIS: I think it shows that the 1.6 though makes a big difference to what you conclude. I mean, you are up at 42 with a 1.6 factor.

MEMBER ABDEL-KHALIK: But the benefit of that is that assures that we will always have a minimum margin.

MR. WALLIS: Does it?

MEMBER ABDEL-KHALIK: Yes. Well this plot doesn't meet that. This plot, the realistic is on this.

MEMBER ABDEL-KHALIK: But if that is the requirement, then it would assure that we will always have a minimum margin.

MR. WALLIS: -- the requirement, they would have to do something about this plant.

MEMBER ABDEL-KHALIK: Right.

MEMBER BONACA: It is slide number 19.

MR. WALLIS: If that were a requirement, I wonder what the impact would be on all these plots.

CHAIR SHACK: Well I think it is way premature. We are just making some observations at this point.

MEMBER RAY: We are not going to do anything.

MR. WALLIS: We aren't going to do anything?

MEMBER RAY: Not now.

MR. LOBEL: Okay, go on to 38. This is has the observations that we were talking about that he conservative and the conservative and the statistical minimum are fairly close so he gives an approximate quantification of the conservative calculation, even though you can't quantify margin in the conservative calculation, this comparison gives some idea of the conservatism in the conservative calculation. And likewise the realistic calculation and the mean.

MR. WALLIS: But you reached this -- this doesn't agree with what we heard this morning. The statistical is very different. It is 95/95.

MR. LOBEL: But I don't think they were doing available NPSH.

MR. WALLIS: Yes.

MR. DENNIG: This morning it was containment pressure with the plots that we were looking at. It wasn't NPSH.

MR. LOBEL: Yes, pressure and temperature.

MR. DENNIG: Right.

MR. WALLIS: Well it is the same thing, isn't it? I mean, pressure is NPSH.

MR. SALLMAN: It was an Hww graph that they were showing in the morning and this is an NPSH graph. They are different.

MR. WALLIS: But the difference for several psi which shows up as feet.

SLES Yes, that's right. This is Hww.

MR. WALLIS: It is the same thing. Hww says feet instead of psi.

MR. LOBEL: Well the only difference is that Hww, to get available from Hww, you just add a constant.

MR. SALLMAN: Add the level of suppression coolant to the central line of the pump and subtract the losses.

MR. WALLIS: But the difference between the Monte Carlo and the conservative, whether it is NPSH or psi, should be consistent because you are just adding the same thing to both.

MR. LOBEL: Right.

MR. WALLIS: But it doesn't explain why this four to six psi difference from what --

CHAIR SHACK: Well unless there is a significant difference in temperature, which changes the vapor pressure.

MEMBER ABDEL-KHALIK: No, no. It is all in there because I mean, what this pressure is the containment pressure required to meet the NPSH requirement. Right? So they are shooting against the same goal and one is significantly different than the other.

This morning, the message to me was that the statistical method bought you several psi.

MEMBER ABDEL-KHALIK: Correct.

MR. WALLIS: And now you are saying it doesn't buy you anything over the conservative. I don't think that is correct.

MEMBER ABDEL-KHALIK: These calculations are not consistent.

MR. WALLIS: No. I mean, the conservative usually is so conservative that it is way above or different from the statistical approach.

MEMBER RAY: This is like saying, isn't it, that if you took 95 to 99, --

MR. WALLIS: They are closer.

MEMBER RAY: You would expect a change to occur but in reality, this would imply what you are just now looking at that no change would occur.

MR. WALLIS: You see, if you look at river water temperature, this is the conservative value. Let's take 90 degrees for the river water. That occurs so infrequently that it wouldn't really show up in the statistical analysis. You would cut off the tail.

MEMBER RAY: Yes. No, I am thinking, you know, five percent exclusion is substantial. And you would expect if you included what is in the tail, it would make a difference, not that it would make no difference.

MR. WALLIS: It makes a difference because the tail is so spread out.

MEMBER RAY: Well, yes.

MR. LOBEL: I'm not sure I have anything to say to that.

MEMBER ABDEL-KHALIK: Other than the fact that your calculation is inconsistent with what we saw this morning.

MR. SALLMAN: Which graph?

MEMBER ABDEL-KHALIK: Any of these graphs. This graph shows that if you do the conservative calculation, you need a lot more containment over pressure to meet the criterion than you would if you were to use this 95/95 method, which means that there is a big difference between the two analyses.

MR. WOJCHOUSKI: Al Wojchouski here. I will try to go ahead and explain is this morning what we were looking at is deterministic in which all of the values were put at bounding peak values and low values. And the statistical was the 95/95 confidence level. I believe what the NRC was doing is their conservative value was realistic and then they added in some uncertainty to it. So it really isn't the same basis as the deterministic. Is that correct?

MEMBER ARMIJO: That is not what I heard.

MR. SALLMAN: The deterministic that you are doing is as same as what is conservative labeled here.

MR. WALLIS: Extreme values of everything?

MR. SALLMAN: Yes, the conservative input values that were used.

MR. WALLIS: Well I can't believe that they are on top of each other because the tails are so spread out.

MR. SALLMAN: Which curve on the GE report are you comparing with which curve? Can you read the sheet number on that?

CHAIR SHACK: Page 20 and 21.

MR. LOBEL: We have the same trend for pressure required but for conservative required and realistic required, we have the same type of thing. We are talking about NPSH.

MR. SALLMAN: So here is the CAP, containment accident pressure required, which is being calculated by back calculation starting from the NPSHR required and how much wetwell pressure is required. This is not the same calculation, this is not the same graph that you are talking about in sheet 20 of the GE presentation.

If you want to see that comparison, I think it is one of the slides in -- wetwell pressure required which is on sheet numbered 69.

MEMBER ABDEL-KHALIK: If they were both on the same scales, you would --

MR. SALLMAN: Okay here. This is the required wetwell pressure, which has been calculated by a back calculation starting from the required NPSH and then going further up and --

MEMBER ABDEL-KHALIK: But look, the red line and the blue line, they are on top of each other. They are large scales. The red line and the blue line. Okay? They are both available.

MR. SALLMAN: Right.

MEMBER ABDEL-KHALIK: Okay, this realistic available is not the statistical calculation. This realistic available was calculated based on the nominal inputs which we discussed 100 percent power, zero sigma to K heat, 90 degrees F, which is a conservative service water temperature, and we used the relative humidity, which was 40 percent instead of 100 percent. So those are the kind of realistic numbers that were used in the realistic analysis and conservative analysis, the same input as in the GE deterministic analysis.

MS. ABDULLAHI: Different code as well.

MR. SALLMAN: This is the same code.

MR. LOBEL: This one has the Monte Carlo calculations on it, too, for pressure.

MR. WALLIS: I am a bit confused here because your NPSHR is just a straight flat line, whereas their NPSH required seems to be -- there is a CAP required. It must be the same thing.

MR. SALLMAN: No, the NPSH required is a straight line but the CAP is the wetwell pressure required, which is -- going backwards you calculate --

MEMBER ARMIJO: It ought to be the same curve. They look similar but they be offset somewhere.

MR. SALLMAN: And we have in our calculation the required --

This is showing the wetwell pressure required. It assumes the effective value for the conservative calculations, the effective value of the required NPSH was used and we came up with this curve, this red curve.

And the second realistic curve we came up starting from the three percent required NPSH and we back calculated and came up with that realistic curve.

MEMBER ARMIJO: These were done with your Gothic code. Right?

MR. SALLMAN: Yes. Yes.

MEMBER ARMIJO: And the Owners' Group was done with SHEX. I am just eyeballing it but if you plot them with the same semi-log scales and pressure scales, taking into account that you had different assumptions in the analyses, they don't look all that different to me. That is what I am -- peaks are about the same time. The magnitudes are about the same.

So maybe your independent analysis came up with similar results.

MR. SALLMAN: Yes, we have a comparison slide also between the two codes that will come, I think in one or two slides here.

CHAIR SHACK: But still you had another curve up here just a little bit ago, with the Monte Carlo, the conservative, the realistic.

MR. SALLMAN: Yes, that was the same curve but that included the statistical analysis also.

CHAIR SHACK: But again, the problem was there that the Monte Carlo maximum was well above the conservative, which would surprise.

MEMBER BROWN: Page 37.

MR. SALLMAN: Is this the one you were talking about?

CHAIR SHACK: No, in the backup.

MR. LOBEL: Sixty-nine. This one?

CHAIR SHACK: No, keep going.

MR. LOBEL: Seventy.

CHAIR SHACK: Yes, this one. I mean, I can understand the way you guys do a realistic calculation, why it comes out so close to the conservative. I am a little surprised that the Monte Carlo maximum is so different, is above the conservative.

MR. SALLMAN: The reason can be because we are trying to minimize the suppression pool temperature but it doesn't have an effect of minimizing the wetwell pressure simultaneously.

MEMBER ABDEL-KHALIK: You mean maximize?

MR. SALLMAN: No. I'm sorry. Maximizing the suppression pool temperature. And at the same time your parameters will not be able to bring the wetwell pressure to a minimum value.

MR. LOBEL: When you do the calculation, you try to minimize the pressure and maximize the temperature. When you maximize the temperature, that increases the vapor pressure above the water and you are also providing more heat to the non-condensable gas to the nitrogen. So at the point of maximum temperature, you don't have a minimum pressure, if you follow what I am saying.

MEMBER ABDEL-KHALIK: I don't think you are going to be able to explain your way through this because it just doesn't make sense.

MR. LOBEL: Well I am trying to explain why first of all the conservative pressure is above the realistic pressure because the conservative is maximizing the temperature. That is increasing the pressure, the realistic pressure.

MEMBER ABDEL-KHALIK: All along you have been telling us that you have been trying, that conservative means that you are biasing the calculation to give you high temperature and low pressure.

MR. LOBEL: You try to do those two things but you can't do them both at once. So the thing you are doing based on sensitivity studies is you go to the maximum temperature for the limiting NPSH. You made assumptions that limit the pressure but it is not going to be the minimum pressure because of what I was saying because the vapor pressure is going to be higher and because you are heating the nitrogen in the wetwell to a higher temperature.

You can't do both things. You can't have minimum and maximum temperature at the same time.

CHAIR SHACK: Okay. So you are arguing that this looks funny to us because we are just looking at the wetwell pressure.

MR. LOBEL: Right.

CHAIR SHACK: And if we looked at the temperature and we turned this into an NPSH plot, it would look like what we think it is supposed to look like.

MR. LOBEL: And that is another reason why we are trying to emphasize using an NPSH rather than looking at temperature and pressure, because you have got to go through all this thinking when you look at one or the other.

MEMBER BROWN: That is slide 37. That is what I -- the one that has got the NPSH on it. Well, that is consistent with what your through process was.

CHAIR SHACK: Right but these graphs begin to look confusing, yes.

MR. WALLIS: Well, I still don't understand the difference between what we saw this morning and what you showed here. It seems to me that how far you are from getting what you need has got to be showing up in both figures. And one of them is it is four to six psi and on the other one it is nothing, when you compare realistic with conservative or Monte Carlo with conservative. I don't see how that can be.

CHAIR SHACK: Yes, that is difficult.

MR. SALLMAN: Which graph are you talking about?

MR. WALLIS: Going back to this morning. I mean, this morning they said that by using essentially the message was, by using statistics rather than conservative, you could buy yourself four to six psi. Whereas, this message from your figures, you don't buy anything. And it doesn't seem to make sense. I can't follow through the reasons for the difference.

MR. LOBEL: This is the statistical minimum on your calculation? Okay.

CHAIR SHACK: In terms of pressure, we should be looking at the minimum, right.

MR. WALLIS: But NPSH and pressure simply translates by the density of water.

CHAIR SHACK: My mind is starting to warp.

MEMBER BANERJEE: We are moving at warped speed.

CHAIR SHACK: No, the plot actually looks the way it is supposed to look. That is the problem.

MR. SALLMAN: Yes, this curve shows the difference between the required, the realistic and the conservative. And this is more or less what GE Owners' Group had in their curve.

So if you want to see a sheet number 21 in GE's presentation, that is the one we should compare with this sheet number 39.

MR. DENNIG: NPSH in feet is not directly comparable to psi.

MR. WALLIS: Their code is not realistic. Their code is the 95/95.

MR. DENNIG: These are both BSI's here.

MEMBER BROWN: Sheet 21 is pressure, psi. It doesn't say wetwell but it does say -- well, that is what it is. According to the ledger, it is wetwell pressure.

CHAIR SHACK: But if you go back to your slide 70 or whatever it was, we should be comparing the conservative with the Monte Carlo minimum, in terms of pressure. We see the same benefit quote-unquote, that GE seeks. If we are only looking at the pressure.

MR. SALLMAN: Yes, these are all available. They are not required. These are all available. You said this is actual wetwell pressure developed --

CHAIR SHACK: Yes.

MS. ABDULLAHI: Can we take --

CHAIR SHACK: I think we just need to move on here.

MS. ABDULLAHI: Can I ask for follow-up item that they cut over and resolve these to --

MEMBER ARMIJO: Yes, put them on the same scale. But I think you just eyeball them and you can see they are similar. They are very similar. Peaks are about the same point in time. The magnitudes are about the same point in time. The differences between the peaks are similar but you had different assumptions within the analyses.

CHAIR SHACK: What we need are some comparisons where we are comparing the same quantities.

MEMBER ARMIJO: Yes, apples and apples.

CHAIR SHACK: If they are doing required, you need a plot of required. If you are doing NPSH, we need a plot of NPSH from them. But sitting here trying to do these things back and forth in our head just leads to confusion.

Lets get back on the track here.

MR. LOBEL: Shall we do that for the full committee?

CHAIR SHACK: I think so or else we are going to have a disaster.

MR. LOBEL: Okay. This is the comparison we were talking about of SHEX. This is the comparison we were talking about of the GOTHIC code and SHEX for the peak drywell pressure. SHEX gives a higher pressure. Peak drywell gas temperature, atmosphere temperature. SHEX gives a higher temperature. Oh, yes, different accidents.

Like I was saying this morning, the peak drywell atmosphere is calculated with a steam line break and the peak drywell pressure is for a LOCA.

MR. WALLIS: Now this peak pressure is the one that is calculated in order to see if the containment will pop or not, isn't it?

MR. LOBEL: yes.

MR. WALLIS: It is the maximum.

MR. LOBEL: Yes.

MR. WALLIS: It is a completely different thing from what we are talking about for --

MR. LOBEL: Completely different thing. But the next two are the long-term suppression pool temperature response. And the peak suppression pool temperature is higher for SHEX than for GOTHIC.

MEMBER RYAN: Just a dump guy question here. Can you ascribe difference to 200 to 203? Is that a big deal?

MR. LOBEL: No. It shows the trend of the code. That is all.

MEMBER RYAN: But I am struggling with the fact that if it is not statistically different, it is the same number on all four of them coming down.

MR. LOBEL: Primarily speaking, it is the same number.

MEMBER RYAN: Okay so the codes are producing the same result within the certainty of the code.

MR. LOBEL: Absolutely.

MEMBER RYAN: Okay.

MEMBER ARMIJO: Even though the inputs are somewhat different.

MR. SALLMAN: No, these --

MEMBER ARMIJO: These are all the Monte Carlo with the same --

MR. SALLMAN: No, these are all same inputs, more or less the same inputs. I am not sure. There maybe slight difference. But we try to use the same inputs but the two codes are different. The codes are different.

MEMBER ARMIJO: Yes, I understand that.

MR. WALLIS: I am not sure that this is a true statement. I mean a few degrees Fahrenheit in a suppression pool temperature makes a significant difference to the heat required for NPSH, doesn't it? Because the vapor pressure is quite sensitive to temperature when you get up to about 200.

So you can't just look at the number to be a few degrees more suppression pool temperature. It shows up on --

CHAIR SHACK: But the SHEX is on the high side.

MEMBER RYAN: And that may well be but I am trying to understand if this is really one number different from another or it is within the uncertainty of all the inputs. I mean, you have got to propagate error through the calculation and know whether they are different.

MR. LOBEL: But these numbers, there is no propagation of errors or uncertainties or anything. These are just putting single numbers in the input for two different computer codes and it is just showing the difference between the computer codes. And there is some bias to SHEX because it is biased that way.

But like you are saying, you can also see that it is not a huge effect. The codes are pretty much calculating the same thing and they have pretty much the same trends.

MR. DENNIG: This is just trying to isolate on the code per se with this modeling effect and not deal with all of the uncertainties in the analysis. The only parameter that is changing in the test is the name of the code. Everything else is supposed to be the same.

MR. LOBEL: If I were the reviewer and I had the SHEX number and I did a copy calculation and I compared these numbers and I looked at the trends, I would probably say just what you were saying that for all practical purposes, they are the same number and there are some minor differences in the codes.

If the numbers were much bigger than this, then I would start to question what the difference and try to figure out what the difference is.

MEMBER RYAN: I understand the phenomenological but you know, I am still struggling with the fact that you are trying to predict reality and you have got two numbers that are relatively close together and I appreciate Dr. Wallis' point that if that is a real difference, it could have an important impact on vapor pressure and so forth.

But that is notwithstanding the fact that are these calculationally different or not. I mean, you only have a fancy calculation with a round-off error and a system error in here. Right? I mean, it is just not clear what you are telling us.

MR. LOBEL: I am telling you that the SHEX is biased to be conservative for these parameters and GOTHIC we try -- GOTHIC is trying to be a best estimate code in the sense that it has physical models in it, not empirical correlations that are biased to predict a bias overestimate or underestimate of a result.

So the codes have different purposes in a way and I am just comparing the two results. One that we got from a licensee calculation SHEX and one that we did ourselves.

I don't think we are disagreeing that much. Like I say, if the difference was much more than this, then we would be in the mode of trying to figure out what that difference was and going through all the different models and looking at things model by model to see what difference things made.

But this is close enough that we wouldn't bother doing that in this case. The other thing we would look at, like I was saying also is the trend. As long as the curves have the same shape, that would be another indication that things were okay. If for a reason in one place one curve went up and one curve went down, no matter what the peak was, we would be looking at that too.

MR. WALLIS: With this NPSH calculation, you have got the various heads of water and so on which don't change. You have got the pressure drop in the pipe that doesn't change very much. The big actor is the suppression pool temperature. That is the one that is different.

MR. LOBEL: Yes.

MR. WALLIS: When they get 15 degrees temperature difference this morning, in suppression pool temperature, this showed up as something like six psi difference in the required CAP. So a few degrees difference in the pool temperature could have a significant effect on CAP.

MR. LOBEL: Absolutely, yes.

MR. WALLIS: So basically they are all the same because they are four degrees different. That may be worth two or three psi or whatever.

MR. LOBEL: Yes, you are right. That is the significant effect and that is why you try to maximize the suppression pool temperature.

MR. WALLIS: This is a one-to-one correspondence really. I mean, you have changed the suppression pool temperature. You have changed the required CAP. They are directly proportional really in terms of the vapor pressure.

Anyway, it has got to all hang together somehow logically. I would think that is a significant difference.

MR. LOBEL: In terms of the effect on NPSH, yes, it would be at that temperature.

MR. WALLIS: Because it has a effect on the required CAP, yes.

MR. LOBEL: Yes, at that temperature, the vapor pressure would be much different. So by the way --

MR. WALLIS: I don't think the message can be that the codes are predicting about the same value and, therefore, it is okay.

MR. LOBEL: Well, I am talking about the temperature. Again, that is why we are trying to concentrate on the available for these calculations for the containment accident pressure calculations. We are trying to use available as the figure of merit, so to speak. The thing we want to concentrate on because that is what the pump sees and the pump is the thing we are worried about in these calculations and the available also combines the pressures and the temperatures and friction factors and all that stuff into one calculation.

MR. WALLIS: But the way you calculate available is influenced by the temperature of the suppression coolant, isn't it? The available NPSH is influence by the fact that the temperature --

MR. LOBEL: Yes.

MR. WALLIS: So the suppression coolant temperature is different by four degrees and that shows up as whatever it is.

CHAIR SHACK: You sound like we are in agreement, Graham.

MR. WALLIS: Well, I know, but that means that I am disagreeing again with their figure 37, which shows the --

MEMBER ABDEL-KHALIK: The vapor pressure at 200 degrees is 11.5 psi. The vapor pressure at 204 degrees F is 12.5 psi. So the difference is one psi.

MR. WALLIS: That is two feet of water.

MEMBER ABDEL-KHALIK: Right.

MR. LOBEL: Actually, what you are point out is one of the reasons why we don't normally give credit for the decrease in required NPSH with temperature because just a little difference in the temperature values makes a large difference in the vapor pressure. And so whatever you are gaining in required NPSH, you could be losing in margin because of the uncertainty in the temperature because the vapor pressure changes so much more with temperature. So that is another reason to just not allow credit for an increase in temperature giving you a decrease in required NPSH.

Anyway, that concludes what I had to say. We will have an answer for the difference sin the numbers when we come back from the full committee. And thank you for your time and your interest.

CHAIR SHACK: Okay, just a question. When you come to the full committee, I assume you are expecting a letter, even though this is a work in progress.

MR. RULAND: Say again? I'm sorry.

CHAIR SHACK: Even though this is a work in progress, you --

MR. RULAND: That is correct. We are looking for feedback from the committee.

CHAIR SHACK: Okay.

MR. RULAND: And the advantage of a letter is that it is written down and the staff can examine it. But it is ultimately the feedback from the committee that we are looking for. A letter, in my mind, is preferable. But if there some other way you want to give us some background, we are open to that, to but it is a letter we are looking for.

CHAIR SHACK: Okay. Any more questions for Mr. Lobel at this point?

MEMBER ABDEL-KHALIK: Would there be a separate letter on the Owners' Group topical report versus the letter on the staff methodology?

MR. LOBEL: I believe we were giving the presentation on the topical report just because we committed to do that. I don't think we were asking for ACRS approval for the topical report. I don't believe that is a usual thing but we invite your comments.

MEMBER ABDEL-KHALIK: We can decide that, I guess independently. So the presentation for the full committee will be what? Both the topical report and the staff methodology?

MS. ABDULLAHI: It is scheduled.

MEMBER ABDEL-KHALIK: Both?

MS. ABDULLAHI: It is scheduled right now that both of them are being reviewed and the letter will cover both of them.

MEMBER ABDEL-KHALIK: Okay.

MS. ABDULLAHI: Whether they coupled or not.

MEMBER RAY: You say it is scheduled and it sounds like a policy decision.

MEMBER ABDEL-KHALIK: That is a decision we have to make. Right now we have enough time, I guess. We have three hours scheduled for that presentation.

MR. HACKETT: That is exactly what I was going to say. This is Ed Hackett. I don't know if the mike is working.

Basically, that is the decision of the ACRS members to decide. And they may be merit to separating the two out and may be merit to considering them both at the same time but that is really mutuals.

MEMBER RAY: Well, we are not hearing a request for a letter on the topical report, if I am hearing correctly. That is what I said about good.

MEMBER BROWN: Well the critical end result is the guidance that the staff wants to give. The topical report is fundamentally a reference document or a base document fro which to draw their recommendations.

MR. DENNIG: Yes, that is exactly what it is. And basically, we are looking for proof of concept. Is this on the right track? Are we close? Does this begin to address or address to any particular degree concerns? And have we gotten closer to achieving this, resolving this with the ACRS?

CHAIR SHACK: Well you know, one of the key points is the containment integrity. You know, if we just looked at this summary, you know, we had the containment integrity. I think we had an excellent presentation today on internal events. And the question is whether we can conclude from that and if there is any more insight or discussion that we could have on that as to how applicable that conclusion is we extend it to consider external events like fire and seismic. Because this independence of the barriers is fundamentally a question of just how strongly you believe that you have accounted for all possible losses of containment integrity.

And you know, perhaps if we were only concerned about internal events, we might get one answer. If were considering a broader range of initiators, we might get another answer. But I think that would be a critical topic in the overall concept that will need to be discussed.

MEMBER BROWN: Well shouldn't they address that in the full committee?

CHAIR SHACK: Yes.

MEMBER BROWN: So we should have some idea of what external events normally would be legitimately considered in terms of the overall evaluation of the plants, shouldn't it? Appendix K fires, seismic, and what else?

MEMBER RAY: Well, I mean I think he said clearly that they are not prepared to do that.

MEMBER BROWN: I know that is what I heard. But I mean, the full committee, I would imagine, would have some answers to your --

CHAIR SHACK: I don't think they will give answers at the full committee.

MR. LOBEL: I think we can address it deterministically but I am not sure that is what you are asking. You want more than just a deterministic. Here is the inspections we do and here is what it is designed for and that kind of thing. Right?

CHAIR SHACK: I mean, that would be one way to make the argument that there is enough margin there that even if we can't quantify it very well, you know, we are talking about something that is operating at design basis conditions, by and large. You know, we are not out on Level 2, things like that. Whatever argument you want to make but I think that is the fundamental difference up to date has been that we are not ready to assume that containment integrity is a given and, therefore, we have been unhappy with the use of containment accident over pressure. You know, I mean, I think the containment accident pressure.

The guidelines that you have developed, I think certainly think quantifying the uncertainties in the NPSH required. That was one of our problems. I think it is helpful to have both the realistic and the conservative NPS, although I think we need a better definition of what realistic is.

And I don't think that you can really quantify these margins without doing something like the statistical analysis. But that is, again, my opinion but you might want to think about that as just an off-the-top kind of thing.

MR. LOBEL: Yes, I think to quantify the margins, I think you are probably right for the available. I don't know how else you could do it.

CHAIR SHACK: And I think it is a very interesting concept with looking at the integrity of the seal and the maximum erosion rate. But again, whether that is ready for primetime is not clear but I think there are certainly concepts that need to be considered and should be discussed. You know, they have to be addressed either as part of the regulations or finding more data to make them go away.

MR. LOBEL: I think we agree with that.

MEMBER ARMIJO: It is a lot of material to cover in three hours, including the risk.

MEMBER ABDEL-KHALIK: It is in the afternoon. If we have to stay later, we will stay later. It is from 1:00 to 4:00 p.m. Is that correct?

CHAIR SHACK: Well, I guess the question is whether we want to do all the three hours on the guidance and not do the topical report.

MS. ABDULLAHI: And how do you define the margins?

CHAIR SHACK: Well, we are still working on this.

Is there any feeling, any contribution? How would the committee think we ought to proceed with the full committee presentation?

MEMBER RAY: I thought the guidance as presented by the staff was self-contained. I didn't see that it required the topical. I am only trying to make it so we can grapple with this thing in a practical way. It is not that I think we shouldn't write a letter about the topical of we are asked to do so or if we feel a need to do so. But it is an awful lot to get shoehorned into here even with a long day.

MEMBER ABDEL-KHALIK: Will the staff evaluate this topical report with this guidance in mind?

MR. LOBEL: The idea was to put the topical -- the topical report has been around for a long time to just finalize the SER after we have talked with you and put it out with the understanding and I think the Owners' Group agrees that after this guidance is finalized, that there will be a supplement to the topical report.

MEMBER ARMIJO: What is the urgency? I don't see anything with a topical report.

MR. DENNIG: Excuse me. It was not our intention to focus on the topical report. We are interested in the feedback on the guidance.

MEMBER ABDEL-KHALIK: But if you approve the topical report, you are essentially giving people license to follow that methodology. And if you are going to come back with another guidance that contradicts that, then they --

MR. DENNIG: The reason why we did not issue a final SE on the topical report was precisely because we did not want to prejudge what we were going to hear from the industry and from you.

MEMBER ARMIJO: I think you should stay on that same track, then.

MR. DENNIG: You know, take it off the table and say we are done with the methodology now let's talk about some new guidelines. No, the idea is this is one package. But we stared the dialogue with the topical and we have evolved to the guidance and we have incorporated what we learned in the topical into the guidance.

MEMBER ABDEL-KHALIK: I would feel very comfortable if we proceed with evaluating the guidance and then you look at the topical, in light of whatever guidance we agree on, rather than --

MR. DENNIG: Right. We certainly we would not tell licensees that they could do something that was at odds with the guidance that we give them.

MEMBER ABDEL-KHALIK: So if that is the case then we ought to focus the presentation on the guidance, because they will evaluate the topical, you know, based on whatever.

MEMBER BANERJEE: And I think we should wait for the SE. SER, whatever.

MR. DENNIG: Well our SE will be informed by the guidelines. It is going to float back. We are basically going to say the topical will have to be adjusted to be in line with these guidelines. And that will be the SE.

MEMBER BANERJEE: Well if it conforms, of course, there is nothing to discuss. I mean, if they come up with some new idea, that is different.

Suppose they conform to your guidelines but they have some, you know, different way to do something? It is possible.

MR. LOBEL: That is why this is just a draft and in the meeting we had, we kept saying that we got the question and we kept answering that we are open to suggestions. We are open to changes. We want more data. We want more documents. And they have given us comments and we are hoping for more data now. And we haven't talked to the PWR Owners' Group yet. So there is still a lot of work to do before we have final guidance.

MEMBER ABDEL-KHALIK: But right now on the face of it, there appears to be a very large difference between the topical report and whatever proposed guidance you have.

MR. LOBEL: Yes.

MEMBER ABDEL-KHALIK: And therefore, if

the ultimate goal is to have a topical report approved that meets whatever final guidance you provide, then it would seem logical that we proceed with the evaluation of the guidance and wait on a decision as to whether or not ACRS decides to review the topical report when that topical report is revised to be consistent with the guidance.

CHAIR SHACK: Mario, Charlie, have you got opinions?

MEMBER BONACA: Well, you know, in general I agree with what you said as a path forward. I think there was a lot of progress with respect to the previous times that we talked to each other. I think that we are working out some solution here. There is a lot of material information that can be used to achieve some kind of agreement.

CHAIR SHACK: Should the full committee discussion be focused on the guidance?

MEMBER BONACA: Yes.

MEMBER RYAN: I agree with Said in summary.

MEMBER BROWN: You passed me by. Can I make my observations?

CHAIR SHACK: Well you nodded, Charlie.

MEMBER BROWN: Well okay, I was deferring to Mario, since he was to my right.

I agree with the guidance part. We are focused on that. I would not deal with the topical report at all. That is my opinion.

Number two, after listening to all the discussions on conservative, realistic, min, max, blah, blah, blah, which parameters are where, that is a total, I lost track of them. And it would be useful to have a table for whatever their evaluation is that says okay, here is the Monte Carlo max, here is the Monte Carlo realistic, here is the Monte Carlo min. Here is the deterministic and list the parameters that are involved and say, what are they, just a table that goes across where you say which ones are held, you know, which are important, which are held. Because they say some of them are conservative and some of them aren't, when they start deviating. I couldn't keep track of what was what from one evaluation to the other.

So I don't know how hard that is. Maybe that is an impossible task.

MR. RULAND: We'll do it.

MEMBER BROWN: With the analysis, you ought to be able to do that.

MR. RULAND: We will do it.

MR. DENNIG: It is one of those things where we have been working with it so long we understand what happened without having to write it down. But it is clear that the language that is used has got to be straightened out and you have to see exactly what is going on from case to case in terms of what is changing.

MEMBER BROWN: One of my major concerns is there are obviously some parameters, as I expressed earlier in the meeting, that ought to be constant across the board and other ones that are random can be treated randomly. Now whether that is right or wrong from the standpoint of these types of analyses I don't know.

MR. SALLMAN: We have the list but we did not put it together in this meeting, I guess.

MR. RULAND: The burden is on us to clarify this.

CHAIR SHACK: And figure 37 again, which started a lot of this discussion, I mean, it would help if you could explain why the minimum and the conservative are so close to each other, which seems like a somewhat surprising result.

And given the way that you have described how you have done the realistic, I am a little surprised it is so close to the mean, since that is supposed to be a bounding scenario with some parameter evaluation to account for uncertainties. It just seems funny.

MEMBER BROWN: The difference between uncertainties and a parameter value is that you have got uncertainties in the parameter values but there are some parameters that ought to be, we ought to know how they are handled as parameters and then the uncertainty comes on top.

MEMBER RYAN: I will give you something that catches my eye. You have got 26.62 feet on the calculation of NPSHR effective. NPSHR three percent is 22 feet. You are claiming two extra digits of precision. You know, I want to know is that real or not real. What are we doing here?

MR. DENNIG: You are right.

MEMBER BANERJEE: I think Bill's point is good that you know, this looks like it is too much of a coincidence or if it is real, then there must be a good physical reason for it. And therefore, that should be explained.

MEMBER RYAN: Exactly.

MEMBER BANERJEE: And I think there probably is a good reason for it that it is looking like that.

MEMBER RYAN: The last item is a little surprising.

MEMBER BANERJEE: So let's understand why it is.

MEMBER BROWN: The last item that I had in my mind was the containment. You brought it up, was the containment integrity thing. That is assuming that it is going to be maintained all the time is that is a tough one to come through.

MEMBER ARMIJO: And that you have got plenty of margin.

MEMBER BROWN: Exactly. I mean, that just has to be the mental level that I come from.

MR. LOBEL: Well when you say containment margin, what do you mean?

MEMBER ARMIJO: Providing all the pressure we need for the pumps to work that we somehow don't forget that there is a containment there, we don't do something that could damage it.

MR. LOBEL: Okay.

MEMBER ARMIJO: And that is really --

MR. LOBEL: Okay. You don't mean above design?

MEMBER ARMIJO: No, no, no.

MEMBER BROWN: But the other issue, I mean, if somebody turns off spray or stops a pump, I am always concerned can you really restart it or is there something else that becomes overriding that you can't restart that if you have to?

And I don't, I mean is there some plant condition, some temperature scenario which does not allow them to re-establish a flow or to re-establish a story or whatever? I just don't know.

MEMBER RAY: Were you asking a broader question of the reliance placed on operator action?

MEMBER BROWN: Part of that, yes.

MEMBER RAY: I have an unresolved issue in my own mind, nothing some thing I --

MEMBER BROWN: No, I agree. You raised it before. I agree with that. Containment integrity, operator actions, and then the consequence of operator actions. Can the systems be re-engaged, if necessary? Because the pressure or the temperature conditions in the plant don't now prevent them. Sometimes some systems, once you start them and they are running, you have primed the pump. It is going. You turn it off, you can't get it going again. Now whether it is applicable or not, I have no idea.

MR. RULAND: So my interpretation of what you are saying is we need to be able to explain to you the types of human factors reviews for situations like this. What the review criteria is and what we are looking for.

MEMBER BROWN: Well the system is would go along with that.

MR. RULAND: I understand.

CHAIR SHACK: Graham?

MR. WALLIS: Well, I am not going to say what the committee should do but it seems to me that focusing on the guidance makes sense. But if I were to focus on the guidance with this kind of a figure, I couldn't take out of my mind the Boiling Water Rector Owners' Group made a presentation. They showed us that we could gain eight feet in available head by using the statistical method, rather than the conservative. This seems to show that there is no gain and I can't accept a figure from the staff knowing that the Owners' Group predicts something quite different. So I can't put out of my mind what the Owners' Group told me and just focus only on the guidance. I think in principal what I see for the guidance looks good but the details really need to be sorted out.

CHAIR SHACK: I think that is sort of part of what we were talking about here is that we need to resolve all these inconsistencies, at least apparent inconsistencies.

MR. WALLIS: Are not going to take into account anything from the BWR Owners' Group presentation?

MEMBER BANERJEE: But that is the mean, right?

MR. WALLIS: No, no. This is the extreme. This is I understand this is the 95/95.

MEMBER ARMIJO: Those things are consistent. No, no. I have looked at their curves and those curves. They are consistent.

MR. WALLIS: No, they are not.

CHAIR SHACK: Curves go up and down.

There are too many discussions.

MR. DENNIG: I think we will just take on some explanation as to why the curves look different. We will provide that.

CHAIR SHACK: Yes I mean, we need to understand whether there really is a significant difference between the staff's statistical calculations. We could all maybe agree on the words. Conservative is the same as deterministic and make sure we are in the same space. Mike?

MR. WALLIS: It is very embarrassing if you approve a guidance which says that the conservative and statistical comes about the same answers so it doesn't matter what they do. And then a plant comes in with a request which shows that they differ considerably. That would be embarrassing.

MEMBER ARMIJO: Yes, this is one example.

MEMBER ABDEL-KHALIK: First, I would like to sort of acknowledge Marty's presentation. I thought that was very enlightening. Thank you. It was very helpful.

And I think despite the sort of concerns about fire and seismic effects and impact on containment integrity I think sort of addresses at least a big chunk of the question.

The second thing is, you know, we need to when we sort of evaluate justification for allowing containment accident pressure versus design changes with the practicability of the changes, I think we should keep in mind the potential conflict between GDC-35 and GDC-38. You don't want to sort of say we are going to keep one and sort of forget about the other. Somehow we have to be able to keep both of these in mind.

The third point, of course, is what came up here is that we need to explain or resolve the differences and define the terminology in whatever calculations you will present. And then finally, and this is just a suggestion that you might want to look at the implications of requiring this ratio of NPSH available divided by NPSH required effective is set above this zone of maximum erosion. What would be the implication of setting that requirement?

I know that my colleagues may not agree with that, inasmuch as that would provide a minimum margin but at least I would like the thought process to begin as to what the implications of that might be.

CHAIR SHACK: Same?

MEMBER ARMIJO: Yes, I think we covered this. Stick with the guidance. Don't mess with the Owners' Group stuff. There is no urgency to it and it is out of sequence anyway and there is so much to cover.

I think Marty's presentation was very helpful to me. It all hinges on the risk. If you really believe that the risk change is trivial, it is kind of hard to say you shouldn't do it. But there is this fire. There is the seismic. Our concern about people doing things that is counterintuitive about systems that are there to protect the containment.

So you know, that is what I would emphasize. I think when it is all over, I agree with Rich and Ahsan that these are, the Owners' Group stuff and the work that they did looks to me like it is very consistent. It is not identical.

But anyway, if you could plot everything on the same scale when you get to that point, I think everything will sort itself out. That is all I have.

CHAIR SHACK: Harold.

MEMBER RAY: I have said a lot. I will try and keep it very brief. I agree with I think everything I have heard up until now.

I am concerned that we become so focused on things that we can measure and calculate and set aside the things we can't that we ignore the real issues that we are here to maintain focus on. And obviously I am talking about external events in this case.

But also maybe about whether there is implications here for what we are doing from a process standpoint that are broader. I won't say anymore about that now because I need to think about it some more. That is all I have.

MEMBER BANERJEE: Well I think I agree with all the things that people have said so I won't repeat them but I will say a couple of things.

One is, I found Marty's presentation interesting but I would like to see uncertainties because I don't know how large they are. And once you do that, that will make me feel more comfortable.

The second thing is we have been making a general push in the ACRS to modernize computational methods. And you have seen that previously with reactor physics methods and a lot of other things.

I think something of that nature, perhaps, needs to be taken into consideration here because we are talking about something like SHEX. Whereas the vendor in this case, GEH, has TRACG available to it, which with a little bit of work could be made to work for containment. If it is not already. I mean, I am sure GE is already working on it.

I would like to see the staff of modernization somehow being considered by us and I don't know how it can be reflected in the guidelines but I think, you know, people say it is good enough.

Well donkeys were good enough for transportation, too. They still are but we have cars. Otherwise, New York City or wherever they use horses would be drowning in, you know.

(Laughter.)

MEMBER BANERJEE: So, I think there is a case to be made here that we should try to move forward and try to urge people to do that. And when you do that, then you get rid of a lot of these sort of gray areas that you are talking about. You know, we don't have any sort of quantification of model uncertainties here.

I don't know most of the time whether they have got a condensation coefficient or a heat transfer coefficient. I have no idea what is going on in these quotes. So just blessing them is nothing I feel comfortable about, even though they are within a few degrees and using some other code. There has been no very detailed justification for best estimate or something like that that we have seen. So that is concerning me overall.

I think that is about it.

CHAIR SHACK: Jack?

MEMBER SIEBER: I think the presentations were very good and I think a lot of work has been done. And I think the staff has gone the extra mile to make things understandable to us where we aren't going to attack them ferociously on everything they say. So I congratulate the staff for the work and the effort that they have done to put it all together.

I basically agree with what the other members have said. On the other hand back in the back of my mind still is the independence of barriers. And I note that there is a number of PWRs involved. I think all of those are sub-atmospheric plants.

MR. LOBEL: No. There are some large drys and the rest are sub-atmospheric.

MEMBER SIEBER: Okay. But perhaps the independence with barriers has been given away a long time. On the other hand, every time that we approach that I think we ought to think very carefully about it because it sort of makes a way at one of the basic tenants of the design and safety philosophy for these plants. And somehow it bothers me. On the other hand, I am not sure it bothers me enough that I would veto the legitimate need for consideration such as are being proposed right now.

So I would like to thank the staff very much.

MR. WALLIS: Can I ask a question now? I am supposed to write a report for the committee. Now is all I have to go on for the guidance this presentation? Is there nothing else?

CHAIR SHACK: No, there is a guidance document you should have gotten.

MS. ABDULLAHI: It will be in the CD.

MR. WALLIS: I haven't got a CD. I never got a CD.

MS. ABDULLAHI: Yes, but I just mailed you the stuff.

MR. WALLIS: Well, I don't think you sent me your guidance document. What does this have to do with the BWR and the staff evaluation of that?

CHAIR SHACK: Well at any rate, we will get it to you.

MR. WALLIS: There is a document.

CHAIR SHACK: There is a document and we will get it to you.

MR. WALLIS: Get it to me today?

MS. ABDULLAHI: Five seconds.

CHAIR SHACK: If you have got a stick, I will give it to you now or do you want a paper copy?

MR. WALLIS: No, I can take a CD but I just don't think I have --

CHAIR SHACK: Any other comments?

MEMBER ABDEL-KHALIK: I would really like to add my comments to those expressed by my colleagues here. The staff has done a lot of work and they should be complimented for their effort.

MEMBER RYAN: Here here.

MR. RULAND: Thank you.

CHAIR SHACK: Again then thank the staff. Thank the Owners' Group for their presentation and I think we will probably have some more interesting discussion shortly.

(Whereupon, at 4:57 p.m., the foregoing proceeding was adjourned.)

BWROG Containment Accident Pressure LTR

Alan Wojchouski
Xcel Energy
BWROG CAP Committee Chair

ACRS Subcommittee on Power Uprates
April 23, 2010

HITACHI

Purpose of Presentation

Provide overview of the Licensing Topical Report

- Provides the deterministic method to calculate NPSHa and a statistical method to demonstrate margin inherent in the deterministic methodology

Brief History

2005 – NRC request for BWROG participation

2/8/2008 - BWROG presentation to ACRS on draft LTR

2/15/2008 – LTR submittal

11/20/2008 – RAIs

3/20/2009 – RAI responses

9/29/2009 – Draft SE

10/27/2009 – Comments on draft SE

3/22/2010 - Revised draft SE

LTR Overview

The LTR addresses the following key areas:

- Overview of NPSH evaluation (Section 2.0)
- Available NPSH evaluation of DBA-LOCA (Section 3.0)
- NPSH consideration for Special Events (Section 4.0)
- The safety basis for requesting CAP (Section 5.0)
- The proposed licensing basis methodology for NPSH (Section 6.0)
- Elements of a license amendment request for CAP (Section 7.0)

BWR Mark I Containment

Methodology

Deterministically calculate NPSHa without CAP

- Conservative assumptions for DBA LOCA and nominal assumptions for special events
- Determine wetwell pressure comparing NPSHa to NPSHr

Statistically evaluate NPSHa without CAP if NPSHa lower than NPSHr

- Provides realistic evaluation of the event in support of CAP request based on the deterministic calculations

Use alternative methods if NPSHa with CAP is lower than NPSHr when evaluated statistically

NPSH Overview

$$NPSHa = [Hww] + [Hpl]$$

$$= [(Pww - Pv) \times 144/\rho w] + [Hpool - Hpump - Hloss]$$

Where:

Hww	Based on containment analysis results
Hpl	Calculated by utility using plant-specific input
Pww	Wetwell airspace pressure (psia)
Pv	Saturation vapor pressure at suppression pool temperature (psia)
ρw	Density of suppression pool water (lbm/ft3)
Hpool	Elevation of suppression pool surface (ft)
Hpump	Elevation of pump suction (ft)
Hloss	Suction strainer and suction line losses from suppression pool to pump (ft)

Deterministic Approach

Traditional conservative analysis performed

- Conservative assumptions and input values
  - Bounding values for containment initial conditions

- Resulting pool temperature response is maximized and the available head response is minimized

This approach will give a conservative assessment of NPSHa

Statistical Approach

Takes credit for variabilities in the analysis input values

The order statistics method is employed

- Input variabilities are defined statistically and combined through a Monte Carlo process
- 59 random draws are made from the corresponding probability distributions. Containment pressure and temperature time-histories are calculated for the 59 cases

Allows for calculating more realistic NPSHa values, which can be used to quantify the conservatism in the deterministic analysis

HITACHI

Statistical and Deterministic Approaches Compared

Deterministic approach: Uses either the maximum or the minimum value for each input parameter

- Depends upon which direction is conservative

Statistical approach:

- Input parameters that can be statistically defined are identified and will not necessarily be at their extreme (maximum or minimum) values at the same time
- Remaining inputs are identical to the deterministic approach

Statistical Approach

For the example plant, the following input parameters were statistically defined:

- Initial reactor power
- Decay heat value after reactor SCRAM
- Initial suppression pool temperature
- Service water (ultimate heat sink) temperature
- Initial suppression pool volume
- Initial drywell temperature
- RHR heat exchanger heat removal capability
- Initial drywell pressure
- Initial wetwell pressure
- Initial containment leakage rate

Statistical Approach

Combine variations in the input parameters through a Monte Carlo process consistent with approved TRACG AOO

- Random draws are made from the corresponding probability distributions in order to determine input values
- Calculation of the containment response with one set of randomly drawn input values represents one trial in the statistical process
- At least 59 trials (calculations) are made to obtain statistically meaningful results at 95%-probability and 95%-confidence (95/95) level consistent with the order statistics method

Statistical Approach

Perform plant-specific containment analysis to determine the following outputs:

- Pool temperature
- Wetwell airspace pressure (Pww)
- Pool volume (Hpool)

Based on these outputs, calculate the value of Hww as a function of time for each of the 59 trials (calculations)

- Obtain the minimum values of Hww as a function of time
- The resulting minimum values are used as 95/95 values

Special Events

NPSH methodology for special events (ATWS, SBO, Appendix R) is presented in the LTR

- Brief descriptions of each of the special events
- Similarities and contrasts to the DBA-LOCA NPSH analyses
- Identified conservatisms in Special Event NPSH evaluations

Special Events

The deterministic approach utilizing nominal input values will be used to calculate NPSHa for special events

Should this approach not satisfactorily show that NPSHa – NPSHr $\geq$ 0; then the statistical approach utilizing the mean output values will be used to show the expected realistic response to the event

Example Plant Analysis

Example plant specific data was provided to GEH for NPSH analysis

- Five years of data was used to develop an exceedance probability distribution for each parameter
- Containment analysis input data provided

Plant specific Containment DBA-LOCA NPSH analysis completed

- Three scenarios analyzed
  - Short term < 600 Seconds (using limiting single failure)
  - Long Term > 600 seconds (using limiting single failure)
  - Containment integrity not credited
- Each in two ways
  - Deterministic approach
  - Statistical approach

Figure A-2 Comparison of Suppression Pool Temperature for Long-term DBA-LOCA (with Diesel Generator Failure) between Deterministic Analysis and Statistical Analysis

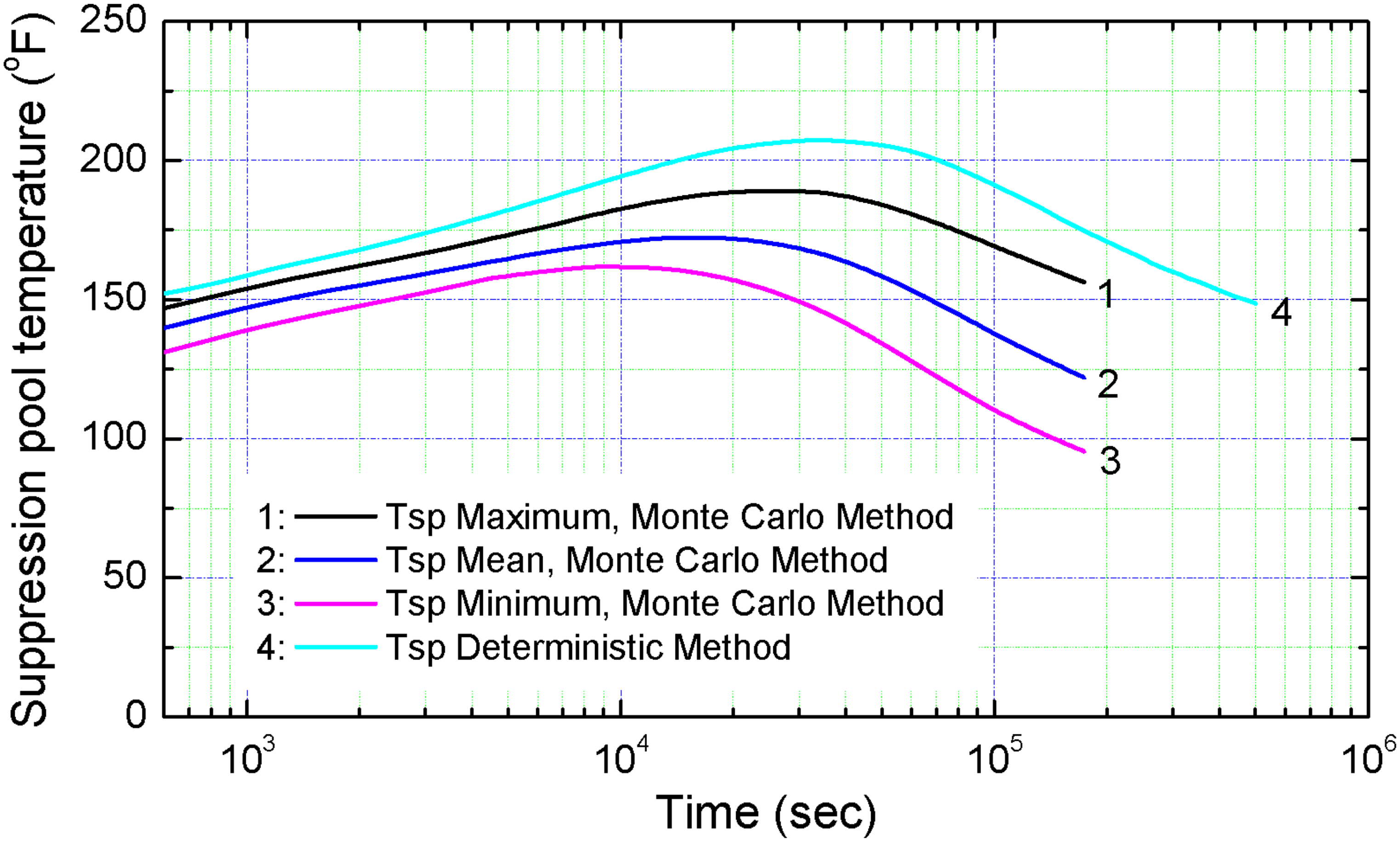
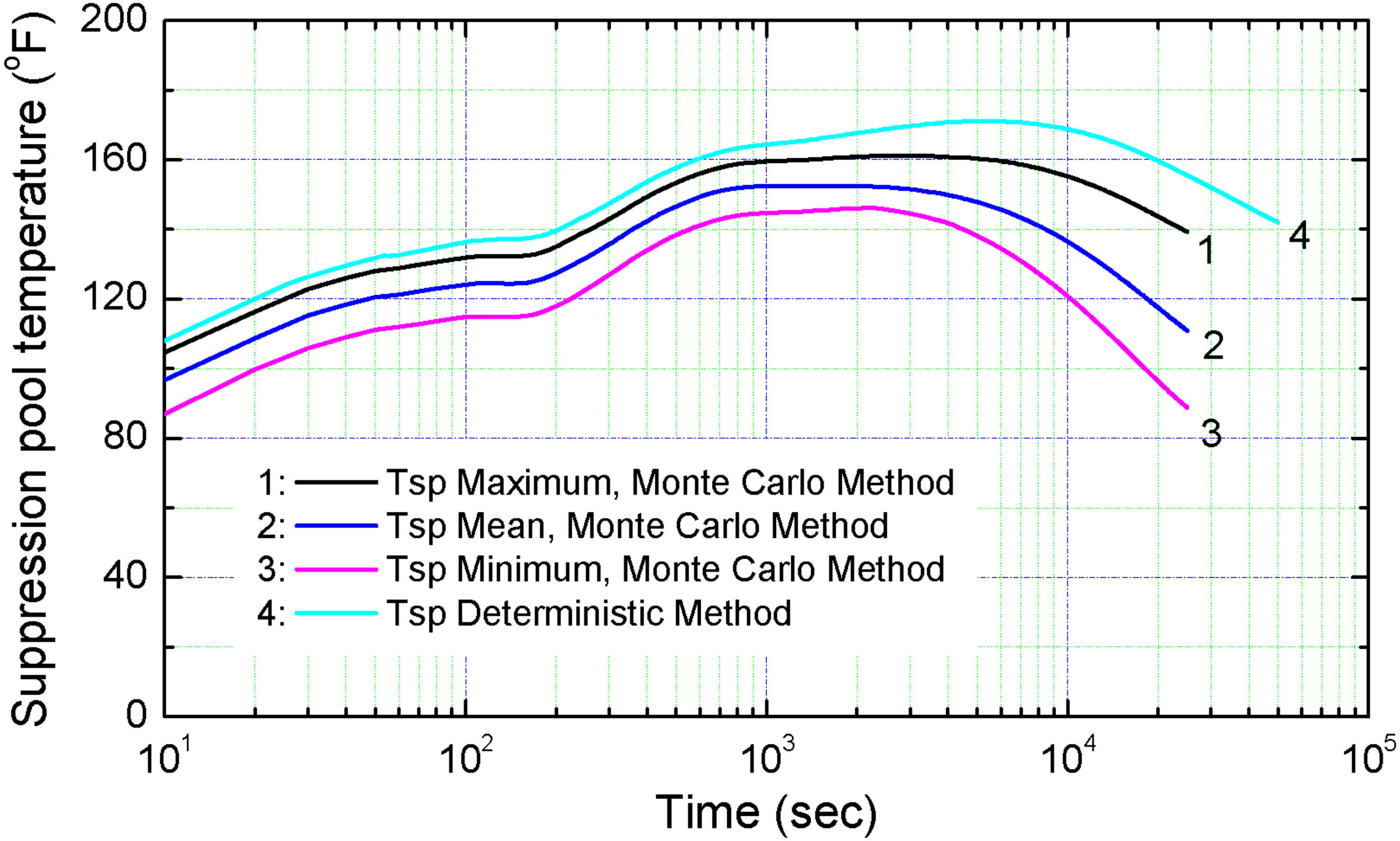
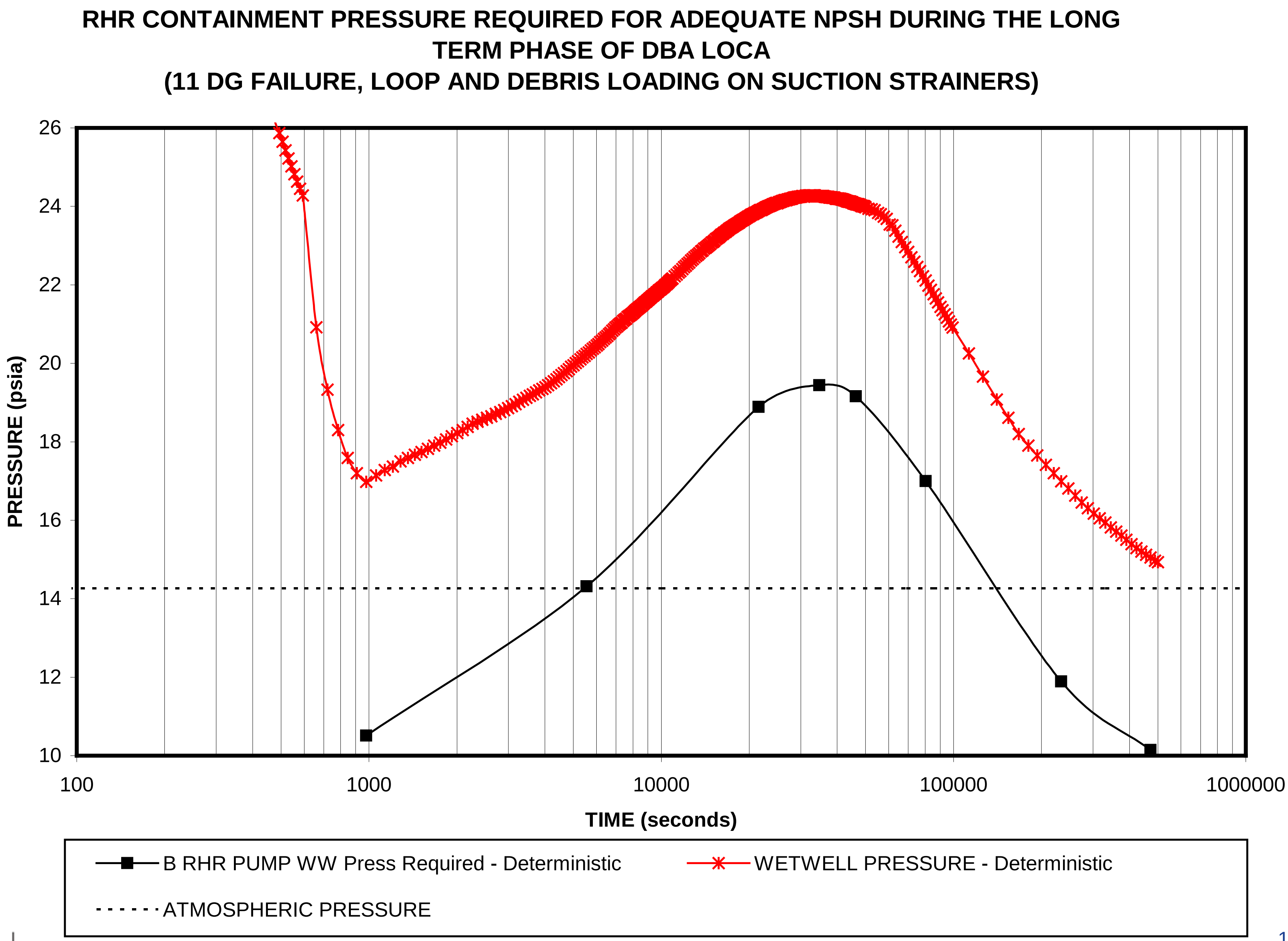
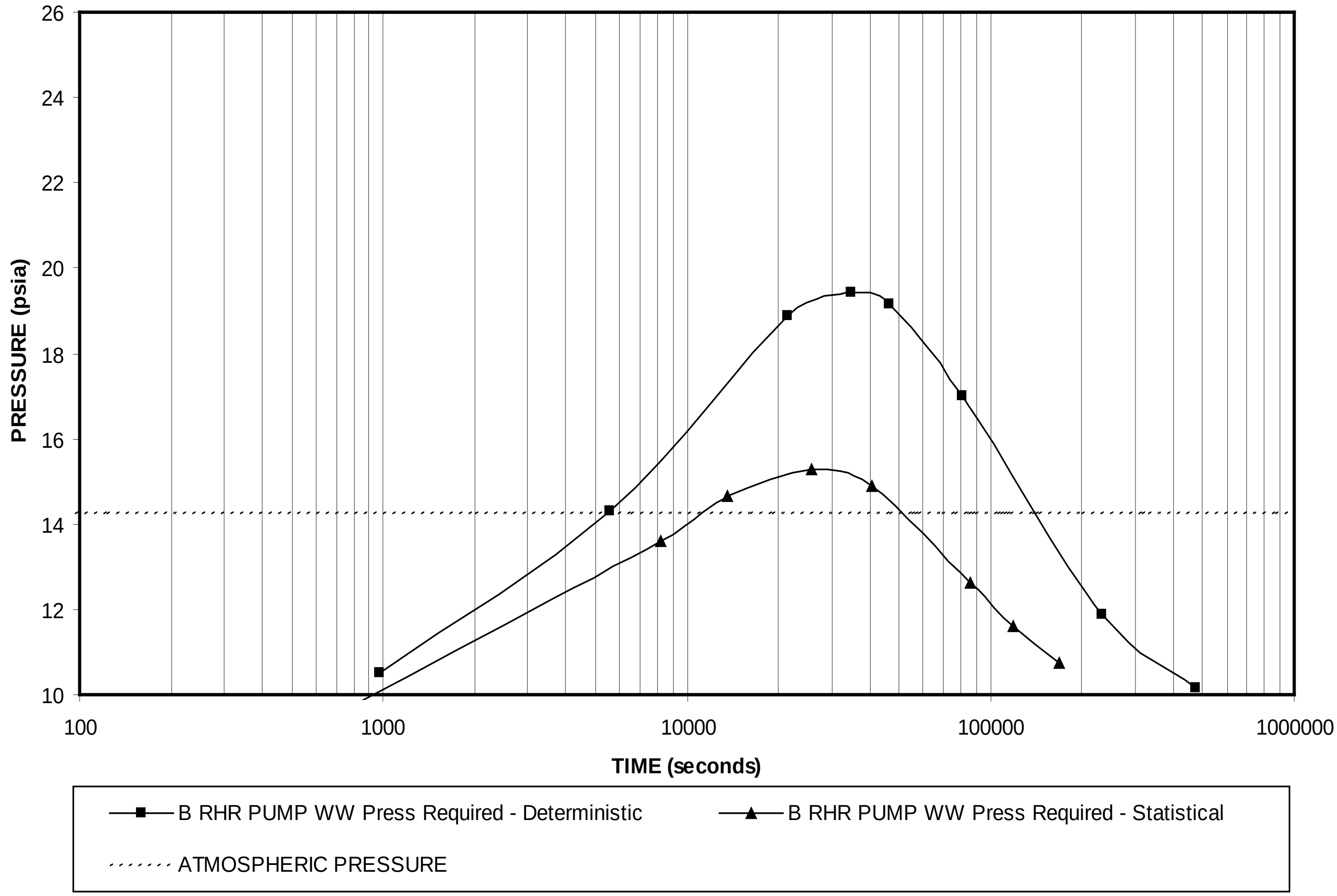


Figure B-2 Suppression Pool Temperature Response to DBA-LOCA with All Safety Systems Available, Containment Integrity not Credited

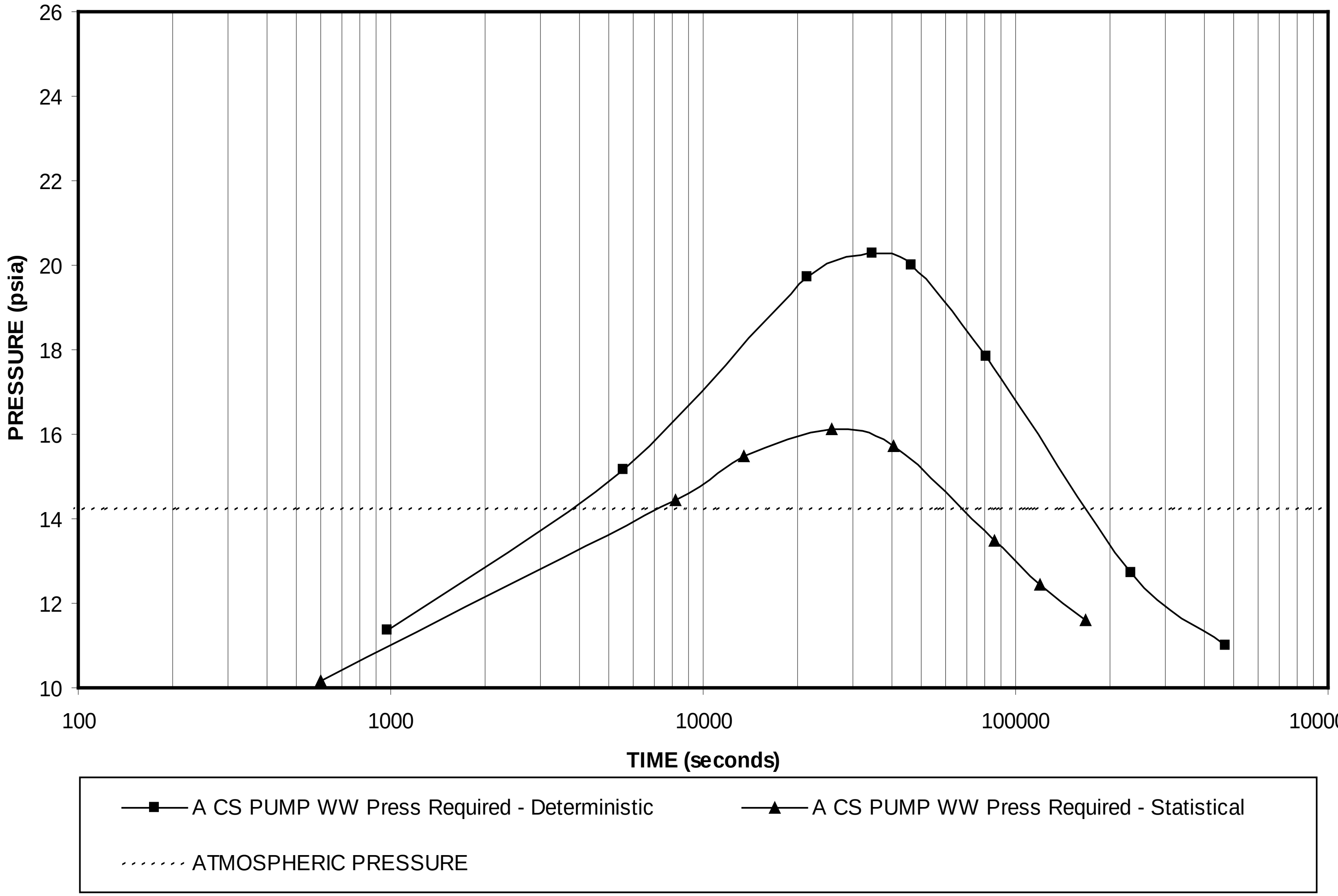



RHR CONTAINMENT PRESSURE REQUIRED FOR ADEQUATE NPSH DURING THE LONG TERM PHASE OF DBA LOCA
(11 DG FAILURE, LOOP AND DEBRIS LOADING ON SUCTION STRAINERS)
PRESSURE (psia)
26
24
22
20
18
16
14
12
10
100
1000
10000
100000
1000000
TIME (seconds)
B RHR PUMP WW Press Required - Deterministic
WETWELL PRESSURE - Deterministic
ATMOSPHERIC PRESSURE

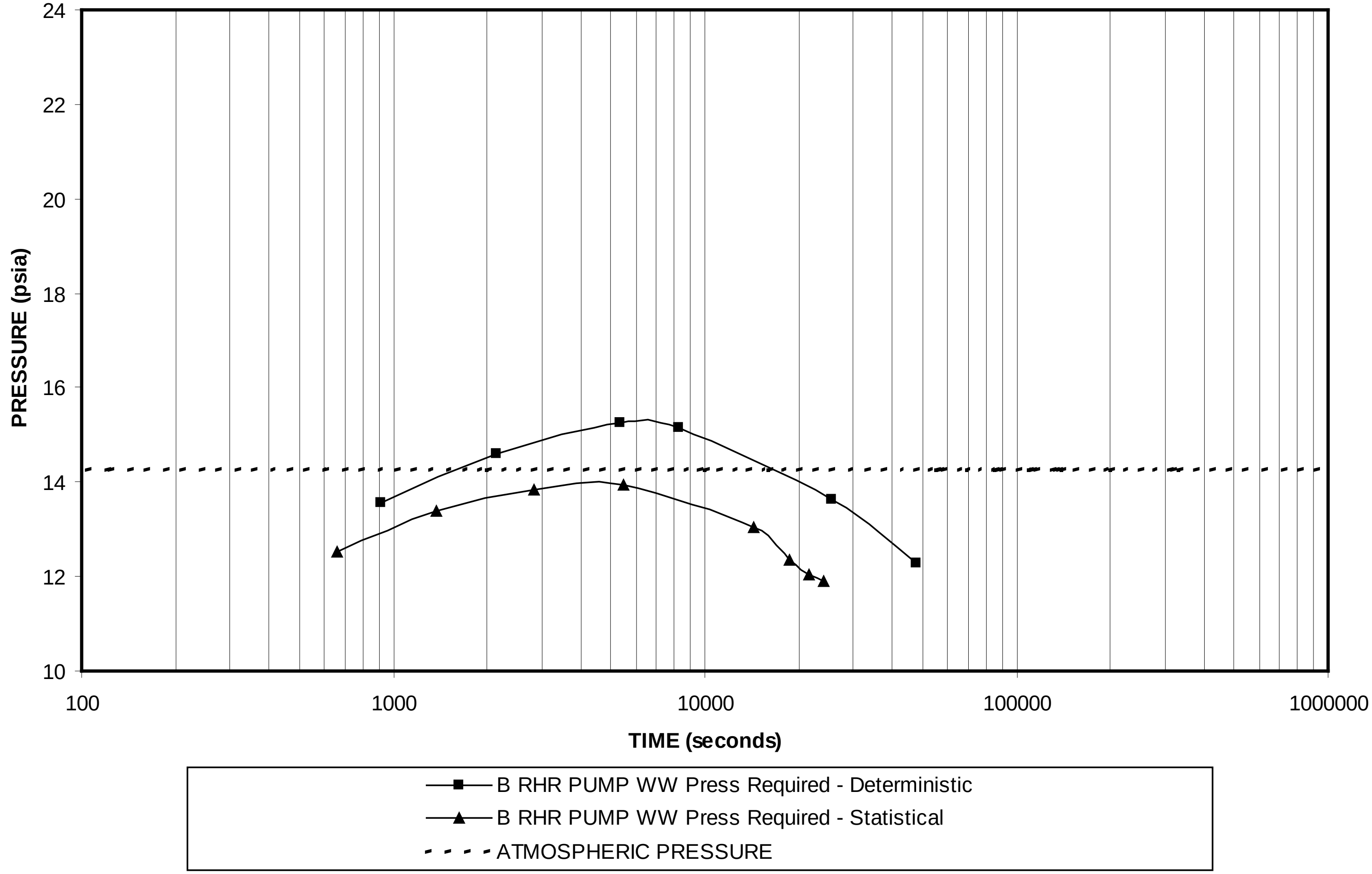
CAP Required for RHR Pumps During DBA LOCA



CAP Required for Core Spray Pumps During DBA LOCA

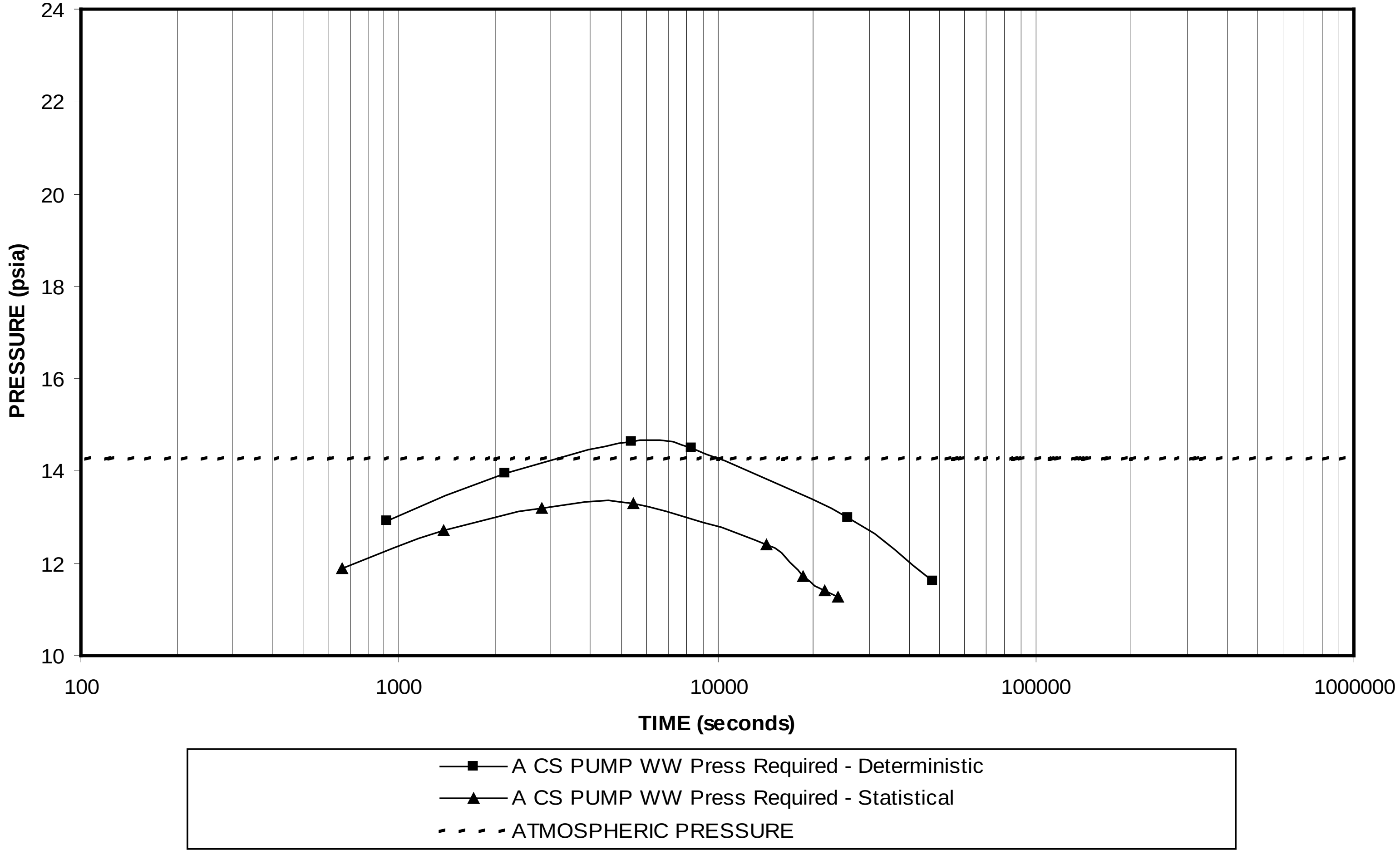


CAP Required for RHR Pumps Without Containment Integrity



HITACHI

CAP Required for Core Spray Pumps Without Containment Integrity



HITACHI

Thank you for your attention

ACRS Power Uprate Subcommittee Presentation

Safety Evaluation of BWROG Topical Report on “Containment Overpressure Credit for NPSH” (NEDC-33347P)

Ahsan Sallman

April 23, 2010

Safety Evaluation of BWROG Topical Report NEDC-33347P

1. Staff Evaluation

- **Regulatory**
  - GDC 35- ECCS to provide abundant core cooling
  - GDC 38- Containment heat removal,
  - SRP 6.2.2-“Containment Heat Removal Systems,”
  - RG 1.82 Rev 3 –provides guidance on use of COP
  - RG 1.157 – provides guidance on regulatory position regarding combining best estimate and conservative analyses

Safety Evaluation of BWROG Topical Report NEDC-33347P

- **Technical**

Deterministic NPSH analysis

- conservative assumptions and bounding values of inputs -
- typical analysis accepted by staff in previous COP reviews
- conservative computer code SHEX- accepted by NRC for licensing calculations

Statistical NPSH analysis

- uses ‘order statistics’ method- NRC approved (see ref 17)
- uses conservative values of some, while remaining input parameters are sampled
- quantifies the uncertainty in the output Hww,
- calculated NPSHA is more conservative than a 95/95.

Safety Evaluation of BWROG Topical Report NEDC-33347P

2. Limitations and Conditions

- Some portions of NPSHa analysis to be reviewed on plant-specific basis
- New staff guidance (draft) requires margin for uncertainty in NPSHR.
- Model other than SHEX should be capable of analyzing LOCA and special events
- Use of best-estimate code shall include of a calculation uncertainty in the statistical method.

3. Topics in TR not Reviewed by Staff

- Risk assessment (section 5.3 of TR) (staff will follow SRP 19.2 Appendix D)
- Accident management to preserve COP, and modifications that would reduce or eliminate need for COP (appendices C & D of TR)- to be reviewed on a plant specific basis

Safety Evaluation of BWROG Topical Report NEDC-33347P

4. RAIs & Responses

- RAI-1 How is the statistical approach consistent with and different from NUREG/CR-5249, "Quantifying Reactor Safety Margins." ?

  Response

  \- consistent- employs some of the CSAU steps, for example determination of reactor input parameter and state, sensitivity calculations,

  \- different-nominal inputs with statistical distributions of these inputs were used for some parameters, while conservative inputs were used for others,

- RAI-4 will the same computer code (SHEX) be used as is in TR? If not what should be the conditions for using a different code?

  Response – not limited to SHEX, aspects of TR specific to SHEX should be evaluated and dispositioned by the licensee if a different containment response model is used.

Safety Evaluation of BWROG Topical Report NEDC-33347P

- RAI-7 - for some BWRs in which MSIV leakage is considered separately from contaiment leakage, how is this considered in the analysis?

  Response- maximum allowed (TS) MSIV leakage should be combined with the maximum containment leakage rate (La) for input as a conservative leakage assumption.

- RAI-10- what type of statistical distribution will be used for variables included in the statistical analysis, ? Will this be determined on a plant-specific basis? What guidance or criteria, if any, are used to determine the statistical distribution?

  Response- normal distribution or with a distribution that represents plant/parameter-specific data, for example- normal distribution for power and decay heat, and parameter-specific for those that can be measured periodically.

Safety Evaluation of BWROG Topical Report NEDC-33347P

- RAI-16- why is it conservative to assume that spray droplets are in thermal equilibrium with airspace before falling to the bottom of drywell or suppression pool?

  Response – spray water being less than DW or WW temperature, the containment pressure would be minimized due to the energy transfer from the airspace to the spray liquid drops.

- RAI-19- How is credit for operator action of throttling of flow included in the analysis for special events?

  Response- The timing for the special events would be dictated by the analysis results and consistent with the operator actions as directed by procedures.

Safety Evaluation of BWROG Topical Report NEDC-33347P

- RAI-34- Section 2.3 states that if COP is required, the most realistic NPSHr should be used. Explain what is meant by the realistic NPSHr value.

  Response: "most realistic" - the standard 3% NPSHr curve, but the "most realistic" term was used to allow licensees the option to contact pump vendors to establish NPSHr values commensurate with the minimum acceptable hydraulic performance.

- RAI-36 - A discussion of the acceptability of NPSHr values used should be included in individual license amendment requests if based on other than 3 percent or 1 percent head drop values.

  Response- BWROG concurs

Safety Evaluation of BWROG Topical Report NEDC-33347P

5. NRC Staff Analysis

- Performed containment NPSH analysis to support the COP guidance
- Will be discussed in the COP guidance presentation

6. Conclusions

- Deterministic analysis shall be the licensing basis, statistical analysis to be used to quantify uncertainty and demonstrate margins.
- Statistically determined NPSHA is not strictly statistical because some of the input parameters are conservative
- Generally similar trend in Hww and Ts shown in staff and BWROG deterministic and statistical analysis

Commission View

- 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.

ACRS View

- 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.

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.
  - Defenses against human errors are preserved.
  - The intent of the General Design Criteria in Appendix A to 10 CFR Part 50 is maintained.

Similar Situations

- Core-damage sequences that involve containment bypass:
  - Interfacing system LOCAs
  - Steam generator tube ruptures
  - Reactor vessel rupture
- Risk-informed changes that involve loss of redundancy or diversity:
  - Allowed outage time extensions
  - Risk-Managed Technical Specifications
- Risk-informed changes that relax programmatic elements which provide defense-in-depth:
  - Risk-informed inservice inspections
  - Risk-informed categorization and treatment of structures, systems and components , 10 CFR50.69

Defense in Depth and the Use of Containment Pressure in Determining Available NPSH

- No changes to any programmatic element 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 Evaluation of Using Containment Pressure to Prevent ECCS Pump Cavitation

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April 2010

Outline

- Overview
- Technical Approach
  - Preliminaries
  - Leak Probabilities
    - Pre-initiator
    - Upon-initiator
    - Post-initiator
- 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:
  - Modify Standardized Plant Analysis of Risk (SPAR) models:
    - Browns Ferry - CAP credit is needed whenever the CS or RHR pumps are taking suction on the suppression pool.
    - Monticello - CAP credit is needed whenever the CS or RHR pumps are taking suction on the suppression pool.
  - Analysis was limited to the study of all internal initiating events that are currently contained in the SPAR models (transients and LOCAs). External events were excluded:
    - Lack of detailed cable routing information to assess the impact on fire on containment integrity
    - Lack of containment seismic fragility information for small leaks

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 failure 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)

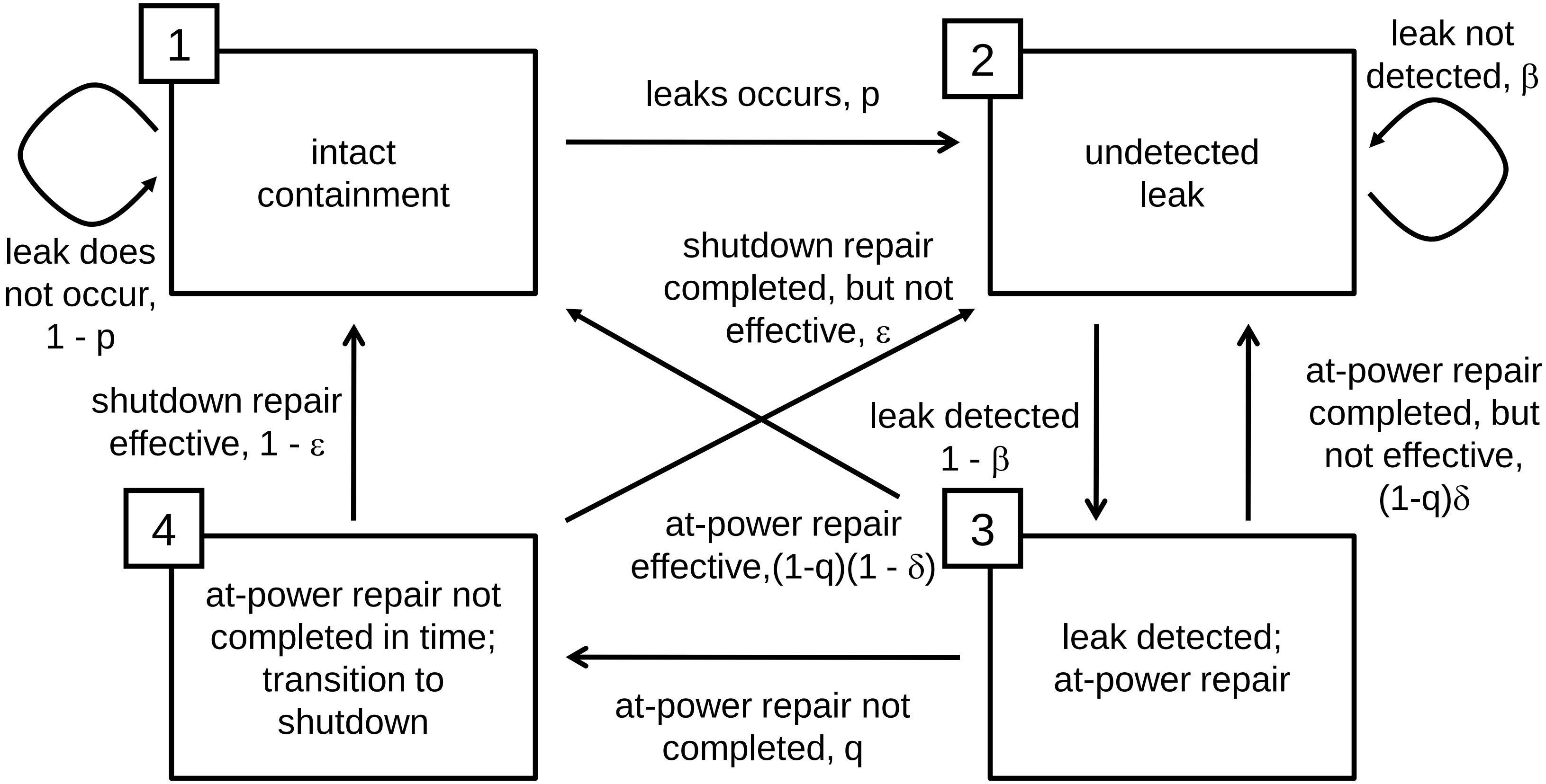
		Actual Containment Condition	
		Leak (true)	Intact (false)
Test Result	Leak (positive)	**true positive** $Pr\{T_P \mid C_T\} = 1 - \beta$ $= \text{sensitivity}$	**false positive** (Type I error) $Pr\{T_P \mid C_F\} = \alpha$
	Intact (negative)	**false negative** (Type II error) $Pr\{T_N \mid C_T\} = \beta$	**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 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.

Semi-Markov Model



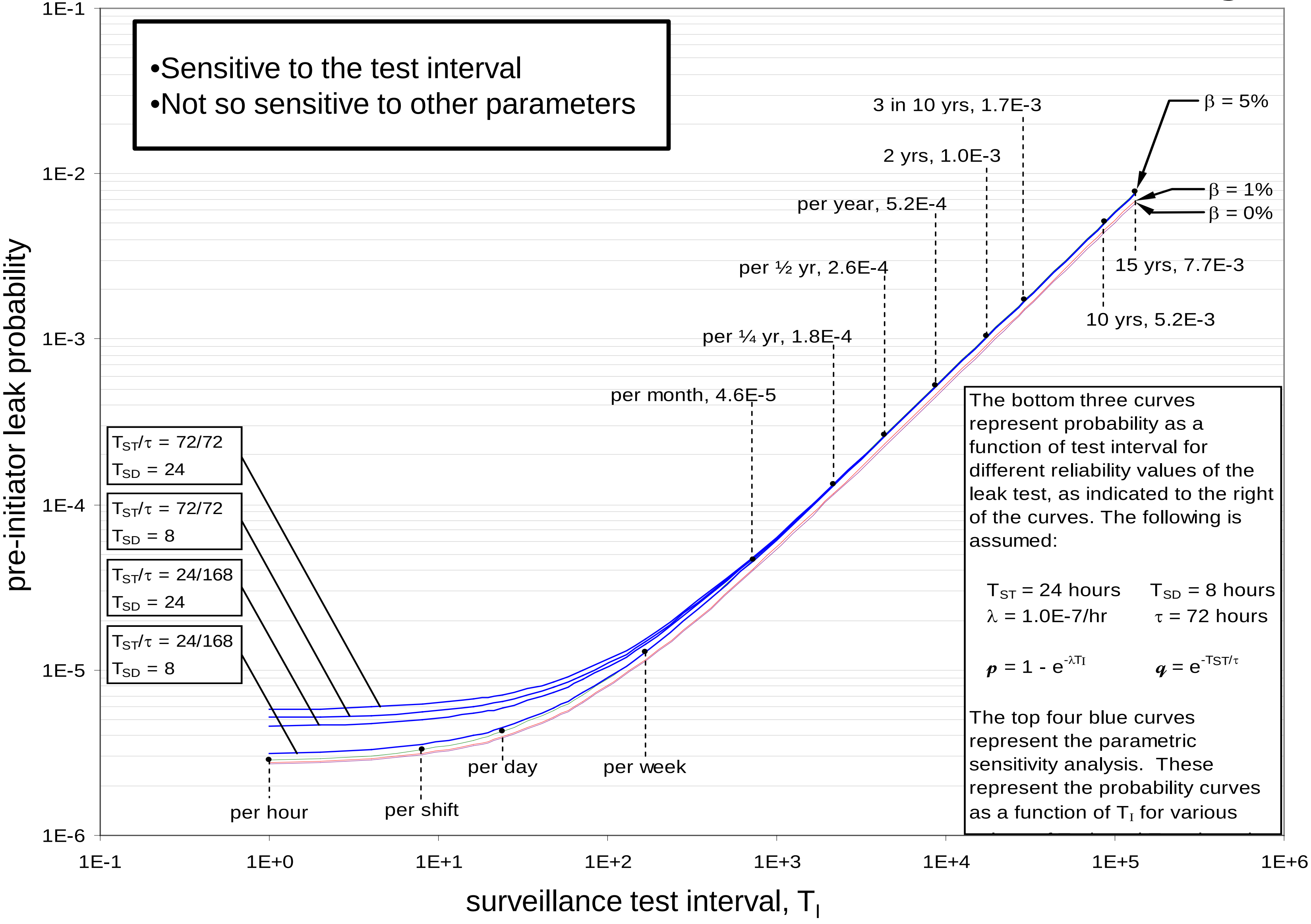
Pr{pre-initiator leak} = long-run fraction of time that the system is in States 2, 3 and 4

Containment Leakage Reliability Parameters

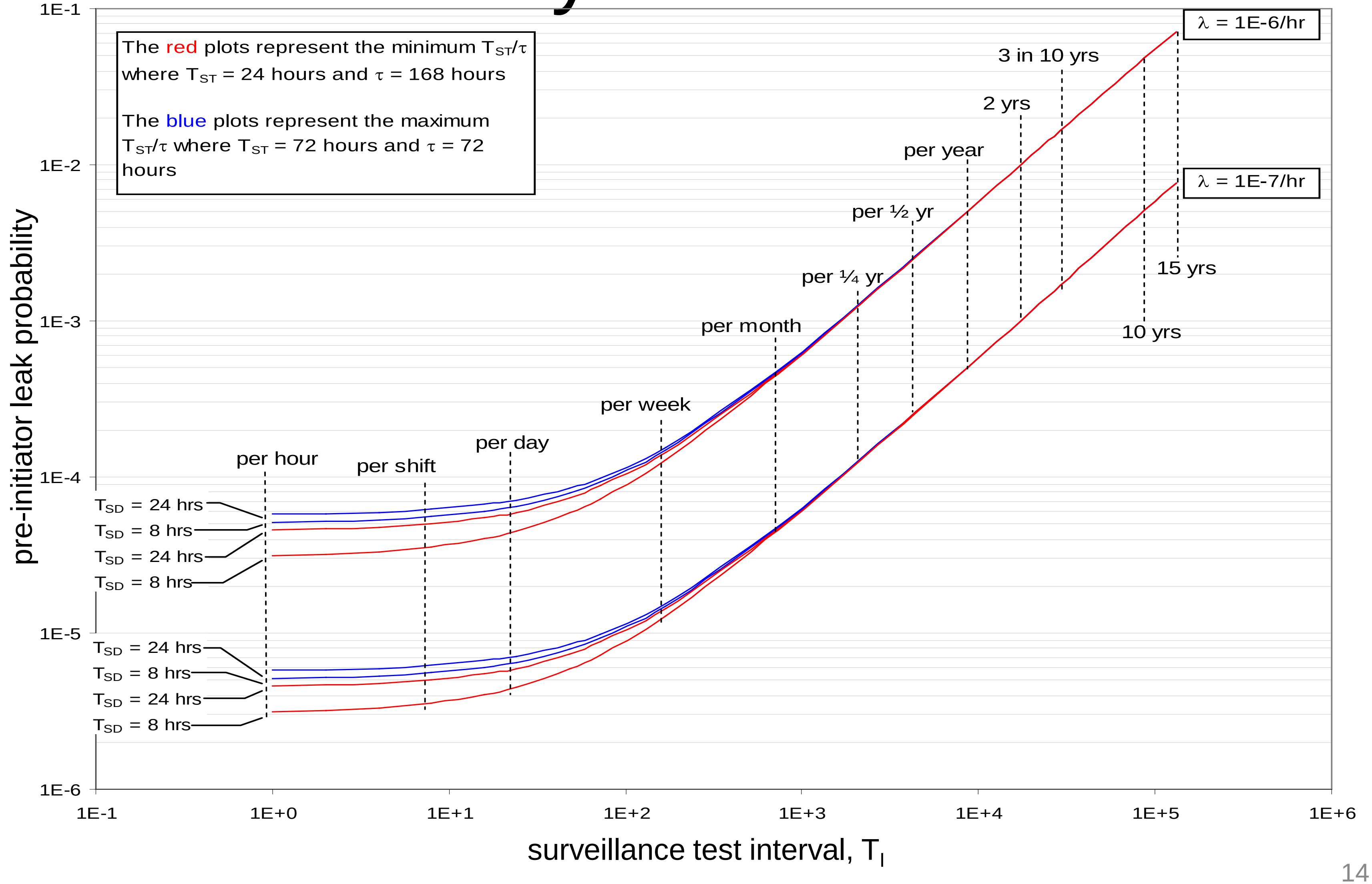
$$\lambda(20\,L_a) = \frac{\Pr\{\text{leak} \geq 20\,L_a \,|\, \text{leak})}{\Pr\{\text{leak} \geq 1\,L_a \,|\, \text{leak})} \times \lambda(1\,L_a) = 1 \times 10^{-7}\,/\text{h}$$

- 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.)

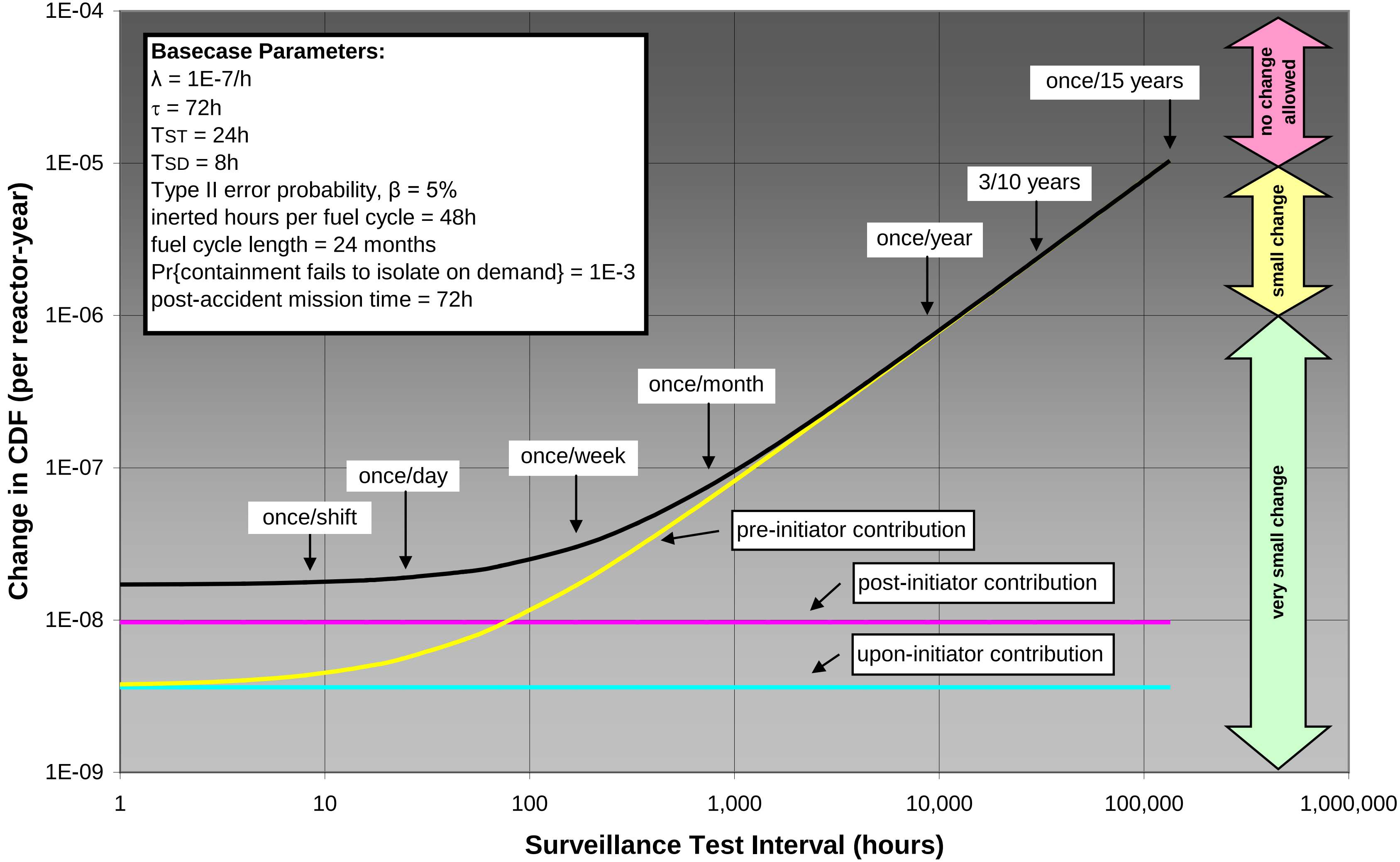
- Following the occurrence of a LOCA (LLOCA, MLOCA, or SLOCA), failure to close the MSIVs introduces a pathway between the containment and the atmosphere.
- The probability that all MSIVS fail to close on demand is about 10^{-4} (including independent and common-cause failures).
- This pathway is a very 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.

$$\Pr\{\text{post} - \text{initiator leak}\} = 1 - e^{-\lambda T} \approx \lambda T$$
$$= (1 \times 10^{-7}/\text{h})(72\text{h}) = 7 \times 10^{-6}$$

Browns Ferry CAP Credit



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 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).
- 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 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

- 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 CDF can be made very small ($<10^{-6}$/y, as defined in RG 1.174) with adequate testing of containment integrity.

Backup Viewgraphs

Average State Durations

M_1	$T_I\left(1-\frac{p}{2}\right)$
M_2	$\frac{T_I}{2}(1+\beta)$
M_3	$qT_{ST}+(1-q)\frac{\tau-(\tau+T_{ST})\exp(-T_{ST}/\tau)}{1-\exp(-T_{ST}/\tau)}$
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

$$P_{234} = \frac{M_2 + (1-\beta)M_3 + (1-\beta)qM_4}{\frac{1-\beta}{p}\left[1-(1-p)\delta - \varepsilon q\right]M_1 + M_2 + (1-\beta)M_3 + (1-\beta)qM_4}$$

USE OF CONTAINMENT ACCIDENT PRESSURE IN DETERMINING THE AVAILABLE NET POSITIVE SUCTION HEAD (NPSH) OF EMERGENCY CORE COOLING SYSTEM AND CONTAINMENT HEAT REMOVAL PUMPS

April 23, 2010

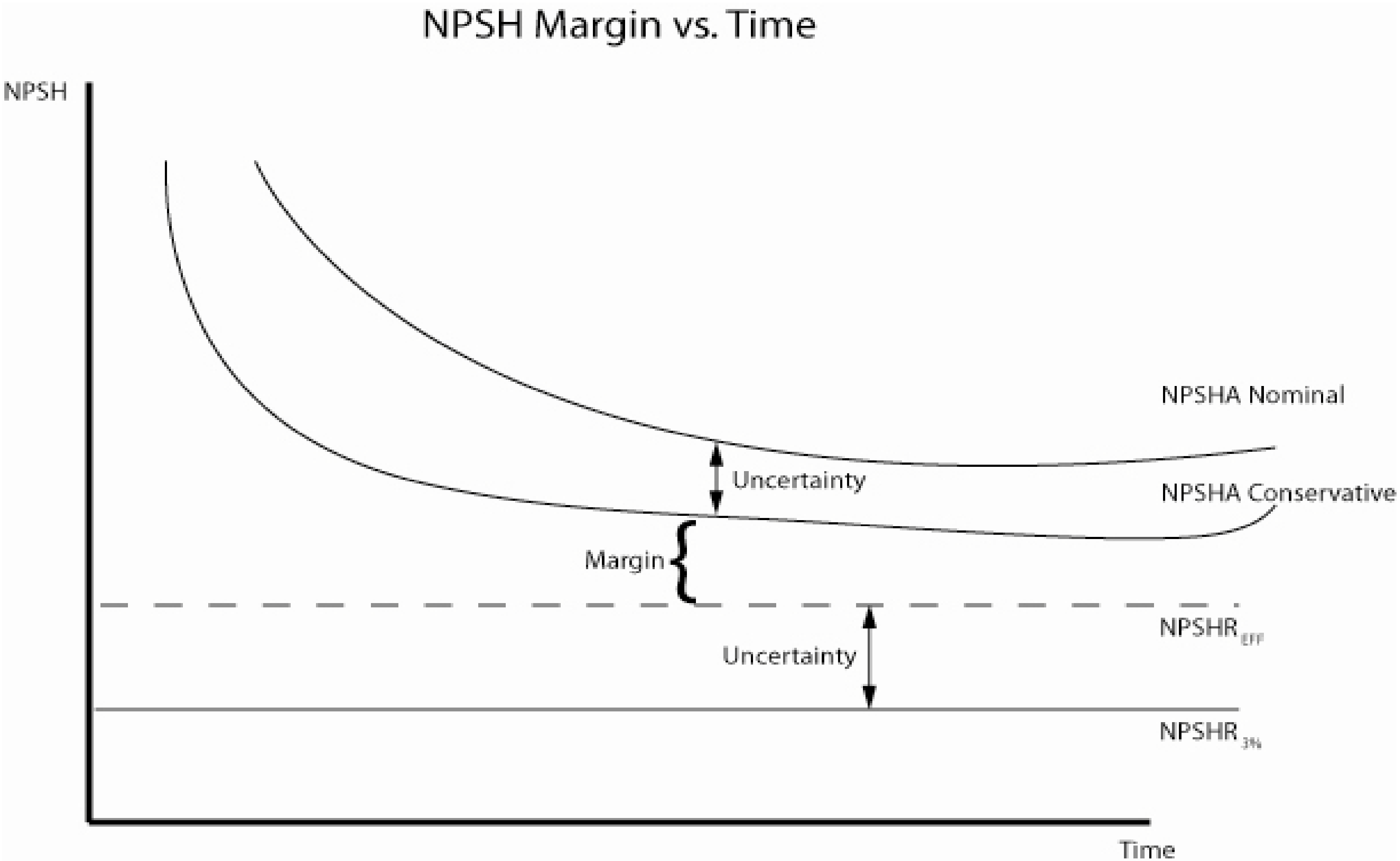
ACRS Power Uprate Subcommittee

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

Margin and Uncertainty



Guidelines-1

- 1. Propose use of $NPSHR_{eff}$ defined as
  - $NPSHR_{eff}$ = (1.0 + uncertainty) $NPSHR_{3\%}$
- 2. Maximum flow rate chosen for NPSH analyses should be greater than flow rate used for core and containment cooling analyses
- 3. Either a conservative or 95/95 lower tolerance limit should be used in determining the available NPSH
- 4. Containment isolation should not be lost due to an Appendix R Fire (associated circuit) or containment venting (required by procedures)

Guidelines-2

- 5. Operator action to control containment pressure is acceptable if justified by human factors considerations and included in appropriate procedures
- 6. Operation for a limited time with NPSHA<NPSHR is acceptable if justified by testing
- 7.Licensees should have capability to detect and take action for a containment leakage rate large enough to adversely affect containment capability to retain accident pressure
- 8. Licensees should justify that use of containment accident pressure is necessary because the design cannot be practicably altered.

Guidelines-3

- 9. Pump operation in the maximum erosion zone should be limited to less than 100 hours
- 10 A realistic calculation of available NPSH should be performed to compare with available NPSH determined from a conservative or Monte Carlo 95/95 calculation
- 11.The mission time of the pump must consider any operation necessary to maintain stable core and containment cooling post-accident.
- 12. 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

Status

- 27 operating reactors use containment accident pressure for determining available NPSH
  - 19 BWRs
  - 8 PWRs
- Extended power uprates:
  - Two EPUs on hold pending revised guidance on use of containment accident pressure for available NPSH

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.

Suction Energy

- Suction energy concept provides a classification of the degree to which centrifugal pumps are prone to adverse effects of cavitation and suction recirculation.
- Suction recirculation is a low flow phenomenon which can result in pressure surges in the pump and suction piping and cavitation.
  - Suction recirculation is not directly related to the issue of using containment pressure to determine NPSH margin
- Suction Energy = D_e n N_{ss} sg
  - n is pump speed (rpm)
  - D_e is impeller eye diameter (in)
  - N_{ss} is the suction specific speed
    - (n rpm) $(Q\ \text{gpm})^{1/2}/(\text{NPSHR feet})^{3/4}$
- Suction energy classified as
  - Low Suction Energy
  - High Suction Energy
  - Very High Suction Energy

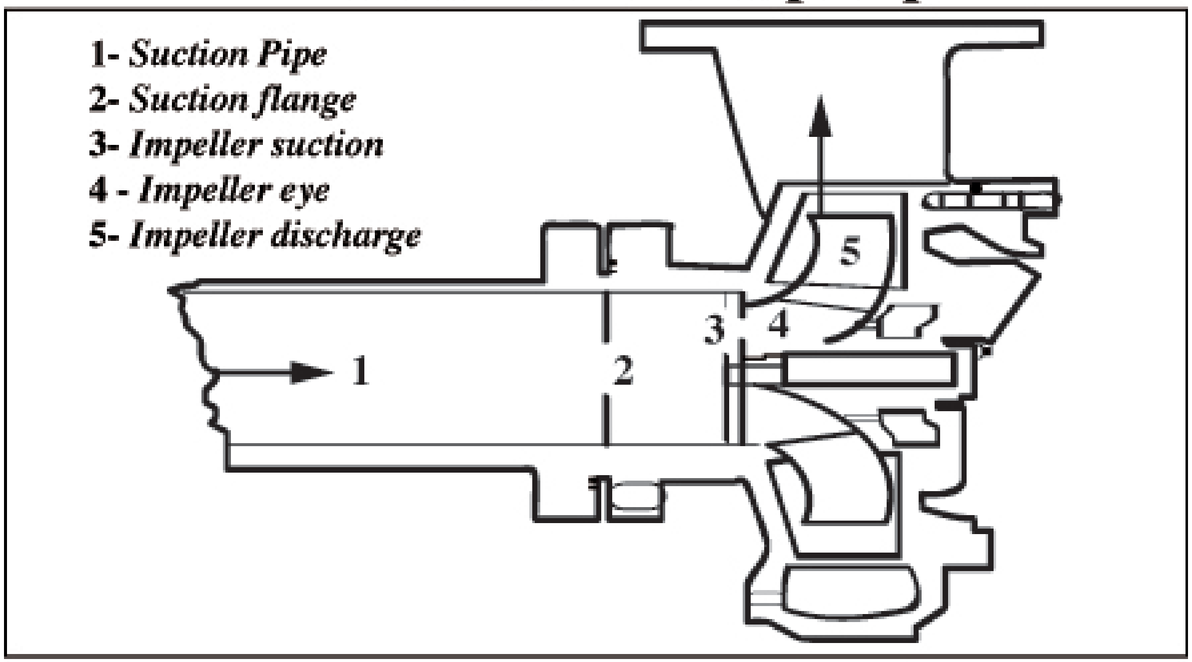
Net Positive Suction Head (NPSH)

- Net positive suction head is the total (stagnation) head of the fluid at the suction flange and the centerline of the impeller relative to the vapor pressure head.
- NPSH can be regarded as an indication of pump suction performance.

Net Positive Suction Head (NPSH)

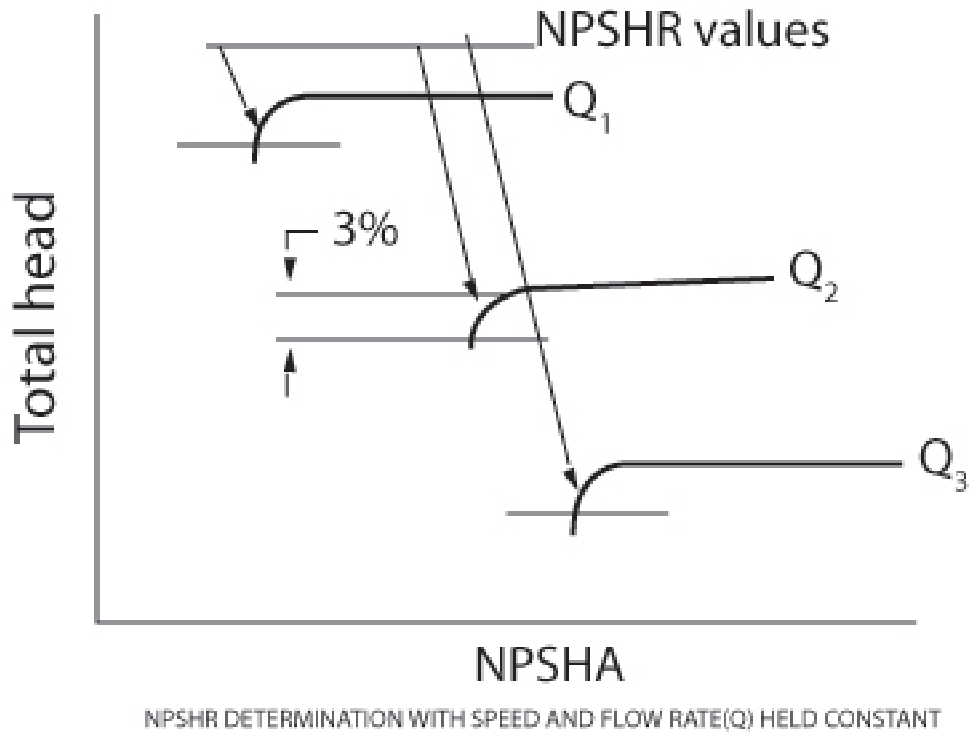
- Two important NPSH values:
  - Available NPSH
  - Required NPSH
- Available NPSH is a function of the system design
  - Obtained by calculation
- Required NPSH is the NPSH corresponding to a specified level of cavitation.
  - Obtained by test
  - Hydraulic Institute defines required NPSH as corresponding to a reduction in pump developed head of 3%
- NPSH margin = NPSHA – NPSHR
- NPSH ratio = NPSHA/NPSHR

Points within the pump



www.cheresources.com, The Chemical Engineer's Resource Page

Required NPSH



- 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

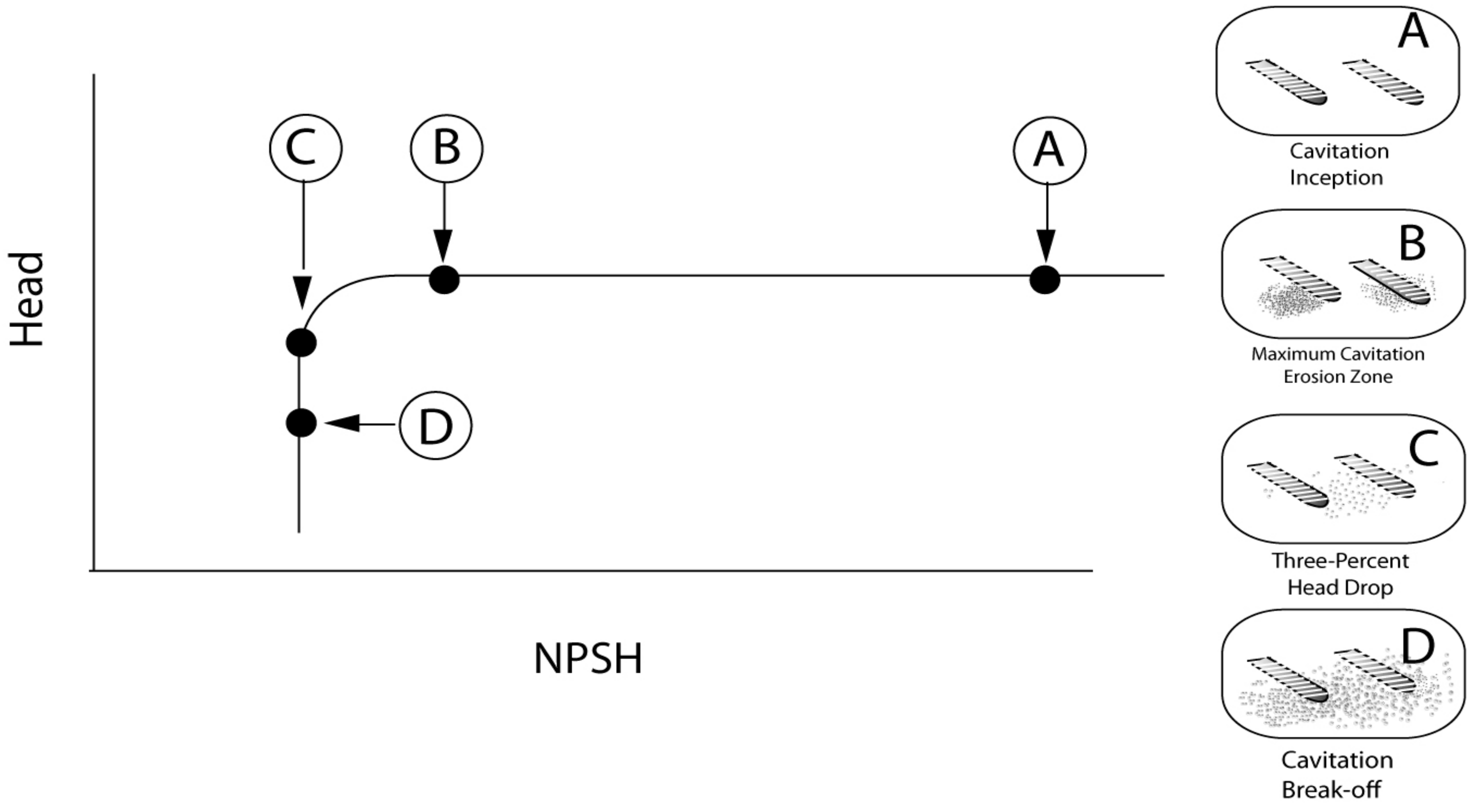
NPSHR Uncertainty Guidance

- Designate new parameter $NPSHR_{eff}$
  - $NPSHR_{eff}$ = (1.0 + uncertainty) $NPSHR_{3\%}$
- Staff requests licenses to determine value of $NPSHR_{eff}$
- $NPSHR_{eff}$ should be used in determining NPSHR margin and NPSH ratio for LOCA
- For nondesign basis events, $NPSHR_{3\%}$ may be used for required NPSH
  - Consistent with current staff guidance for nondesign basis events

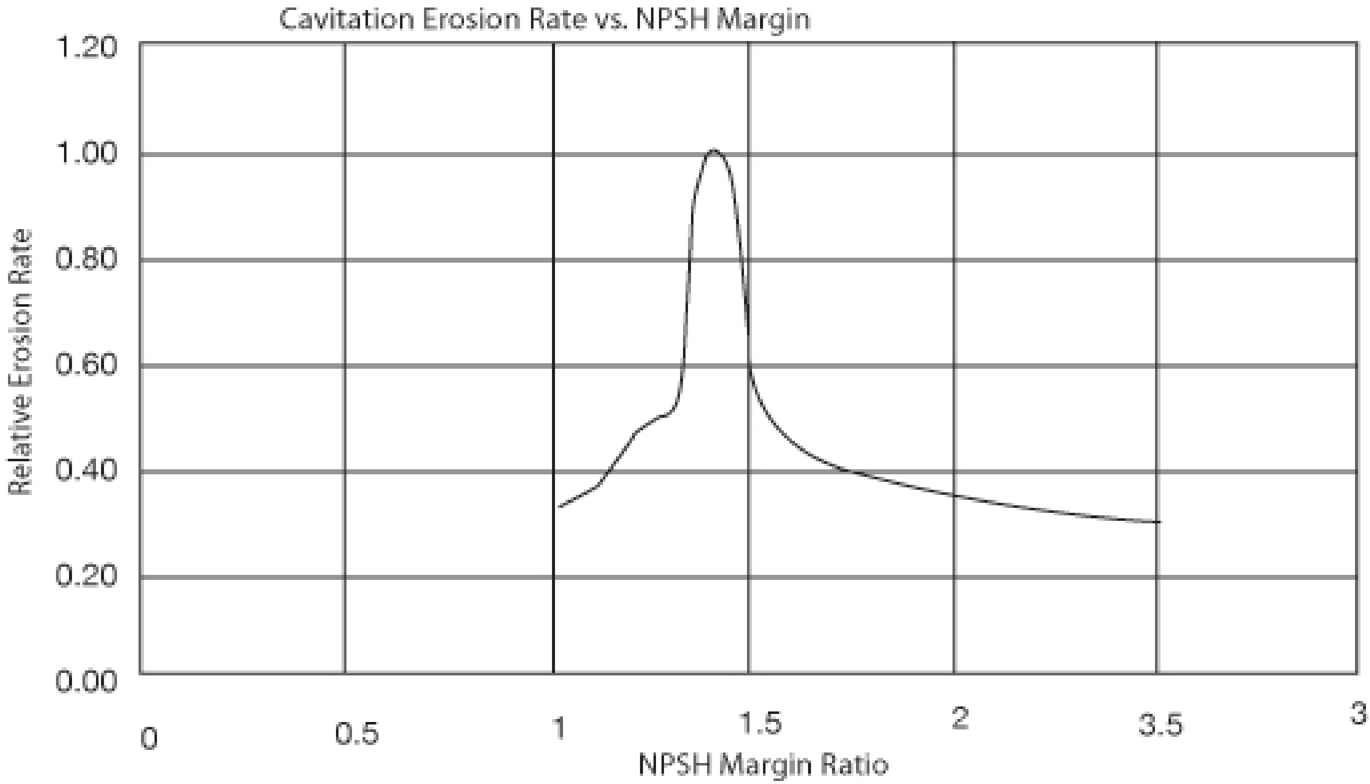
Cavitation Erosion

- 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.
- Based on the failure history of very high suction energy pumps, 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

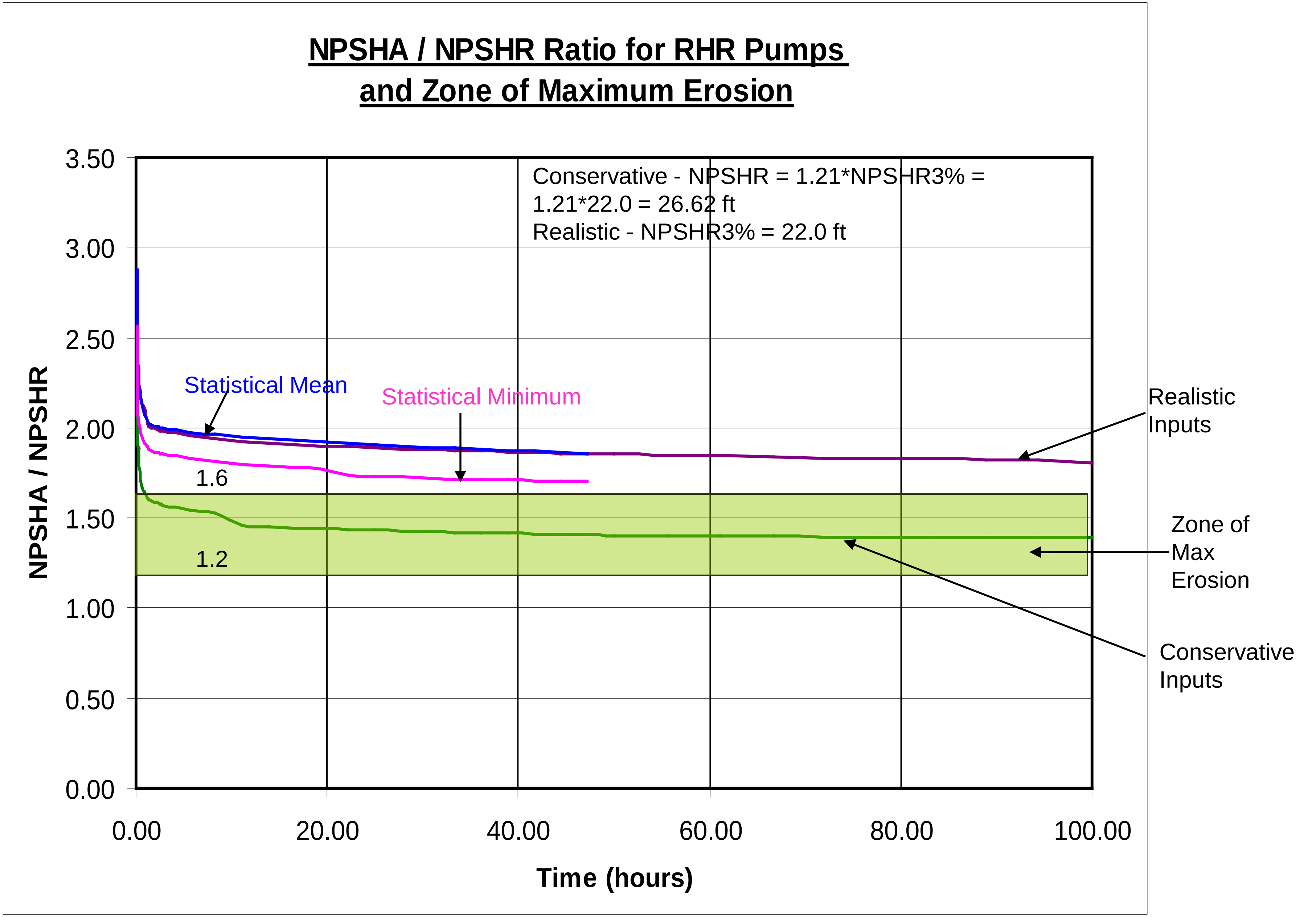
Cavitation Behavior Based on Impeller Voiding



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
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
Time (hours)

NPSHA < NPSHR

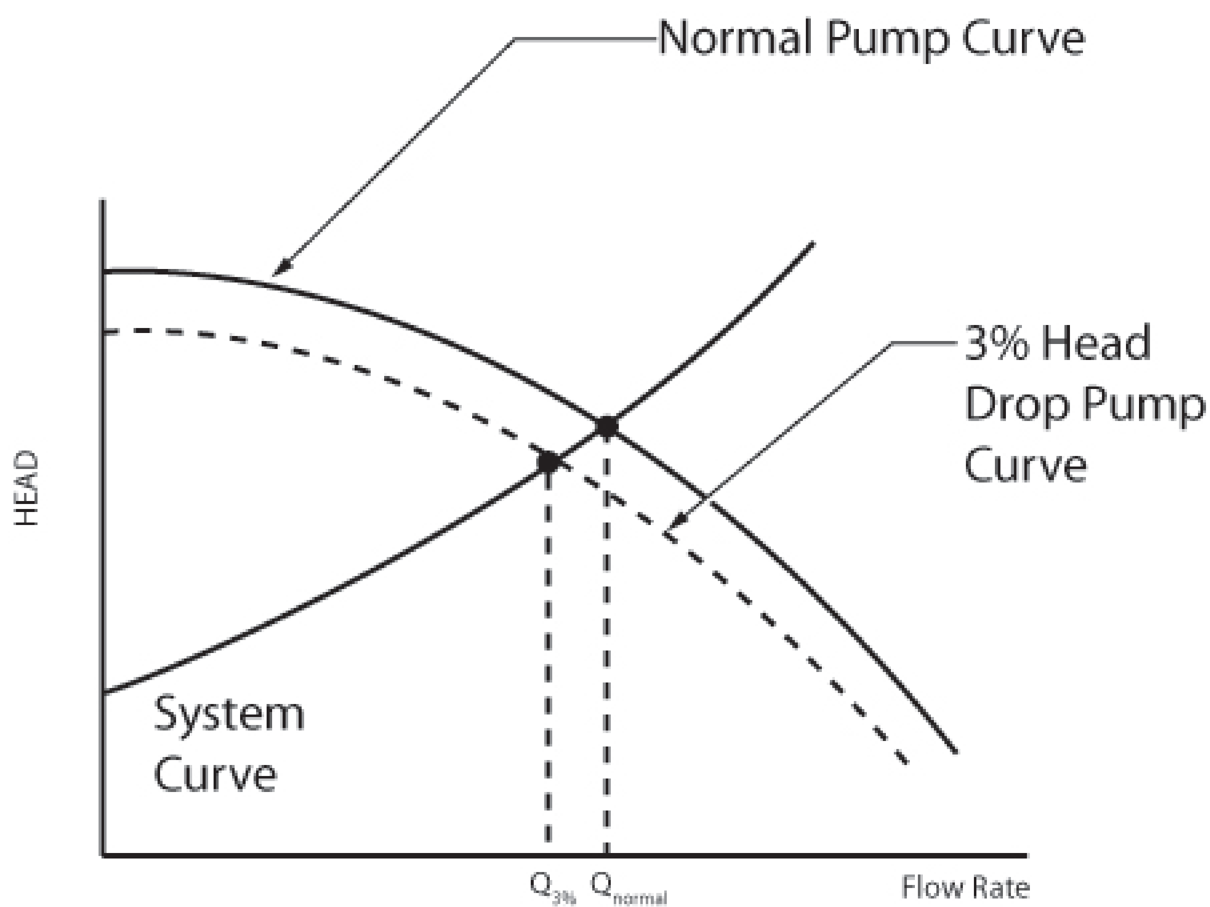
- It is possible that the predicted available NPSH for an event may be less than the required NPSH.
- RG 1.82 Revision 3 states that predicted operation with NPSHA < NPSHR is acceptable if testing shows that the pump will continue to perform its safety function.
- Staff has developed the following conditions 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 tends to 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 equal) should be provided.
  - A pump with a single seal should be equipped with a throttle (disaster) bushing and with a flush line from the pump discharge to the mechanical seal chamber.
- Over the long term, vibration due to cavitation also reduces seal life

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 = $NPSHR_{eff}$ 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

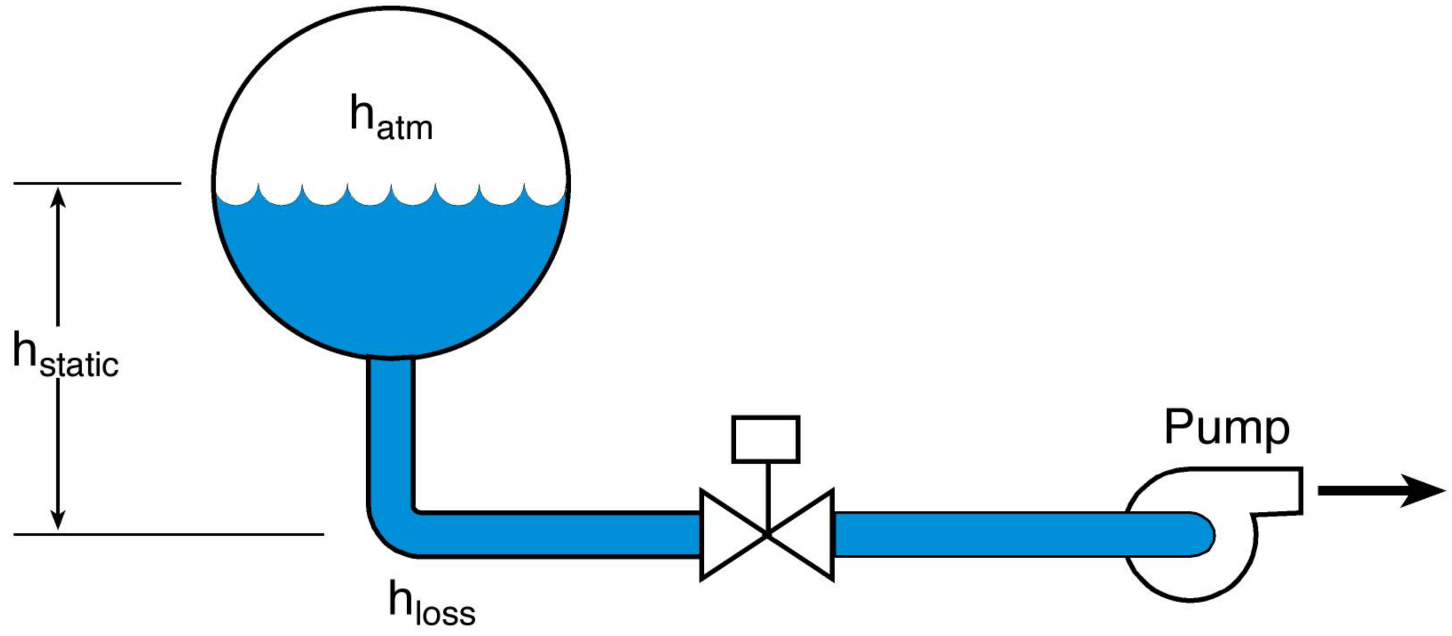
- Licensee analysis should demonstrate that operation of sprays or fan coolers will not cause containment accident pressure to be less than that needed for adequate available NPSH.
  - BWR procedures contain a caution to this effect.
- Operator actions to control containment pressure are acceptable, if justified.
  - Human factors review
  - Actions consistent with procedures
- Containment pressure calculations should be consistent with or conservative to plant procedures.
  - e.g., spray operation rather than suppression pool cooling assumed in BWR NPSH analyses
- Operator error
  - Operator errors (omission/commission) are not considered in design basis and special event analyses

Alternatives to Use of Containment Accident Pressure for NPSH margin

- Staff will request licensees to address the practicality of methods of avoiding use of containment accident pressure in determining NPSH margin

Available NPSH

$$\text{Available NPSH} = h_{atm} + h_{static} - h_{loss} - h_{vp}$$



Containment Integrity

- Containment integrity is assumed in LOCA and special event analyses
  - Accident analyses verify no containment limits are exceeded for design basis and special events
  - Appendix J leakage rate testing and visual inspection
  - 10 CFR 50.55a(2)viii and ix containment inservice inspection
  - Technical Specifications requirements (e.g., valve position verification)
  - Plant Procedures
  - History of containment integrity
  - Proposed staff guidance to implement a surveillance to ensure containment leakage rate less than that necessary to ensure adequate NPSH margin

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 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 or Monte Carlo lower tolerance limit (95/95)
  - Realistic

NPSHA Conservative Calculation

- Conservative calculation uses bounding values or technical specification limiting conditions for operation for important parameters.
- BWROG Topical Report NEDC-33347P describes an acceptable method of performing conservative calculations for BWRs.
- Computer code may or may not have a conservative bias
- Conservative calculation does not explicitly quantify margin

NPSHA Monte Carlo Method

- BWROG topical report NEDC-33347-P, “Containment Overpressure Credit for Net Positive Suction Head (NPSH),” proposes to use a Monte Carlo statistical method which would quantify margin between a specified tolerance limit and the conservative calculation
- Method attaches a statistical measure to a variable $H_{ww} = (P_{ww} – P_{vapor})/\rho g$ which is the portion of the equation for NPSHA calculated by containment code.
  - Pww is the wetwell pressure and Pvapor is the vapor pressure of the suppression pool water.
  - Statistical limits attached to Hww.
  - $NPSHA = H_{ww} + H_{static} – H_{loss}$

NPSHA Realistic Calculation

- Realistic calculation uses nominal (expected) values where possible.
- Where nominal values are not available, bounding values are used, e.g.:
  - Head loss across suction strainers
  - Service water temperature

NPSHA Staff Calculations

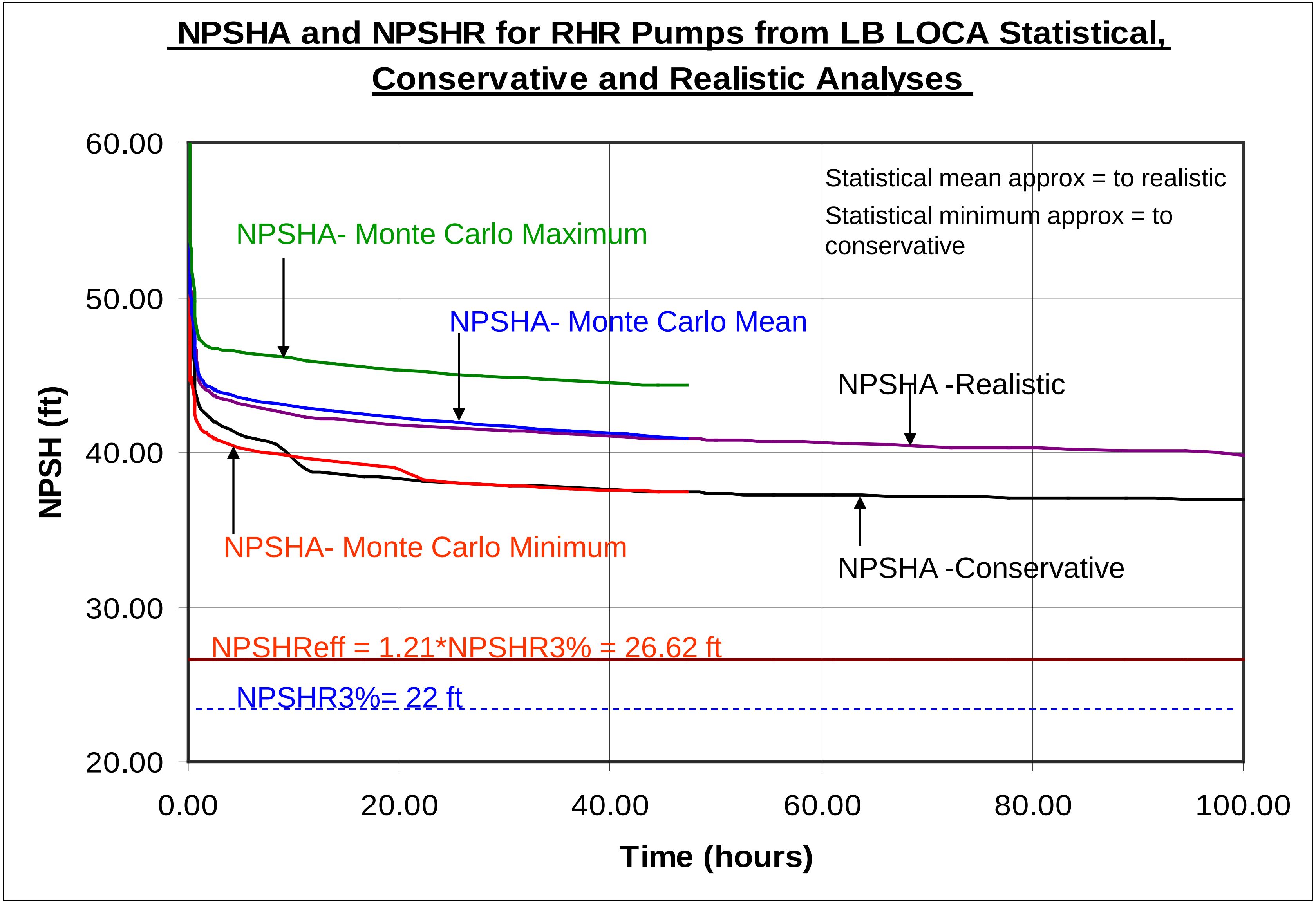
- NRC Staff performed calculations using the GOTHIC (Generation of Thermal Hydraulic Information) computer code, Version 7.2a.
- GOTHIC is a general purpose thermal hydraulics computer code for analysis of nuclear power plant containments and other confinement buildings.
- Solves conservation of mass, energy and momentum for multi-component, multi-phase flow.
- Interface models allow for thermal non-equilibrium between phases and unequal phase velocities.
- Subject to requirements of 10 CFR Part 50 Appendix B

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
- Each variable varied by 5%.
- Conservative inputs used for base case (except 100% power instead of 102%)

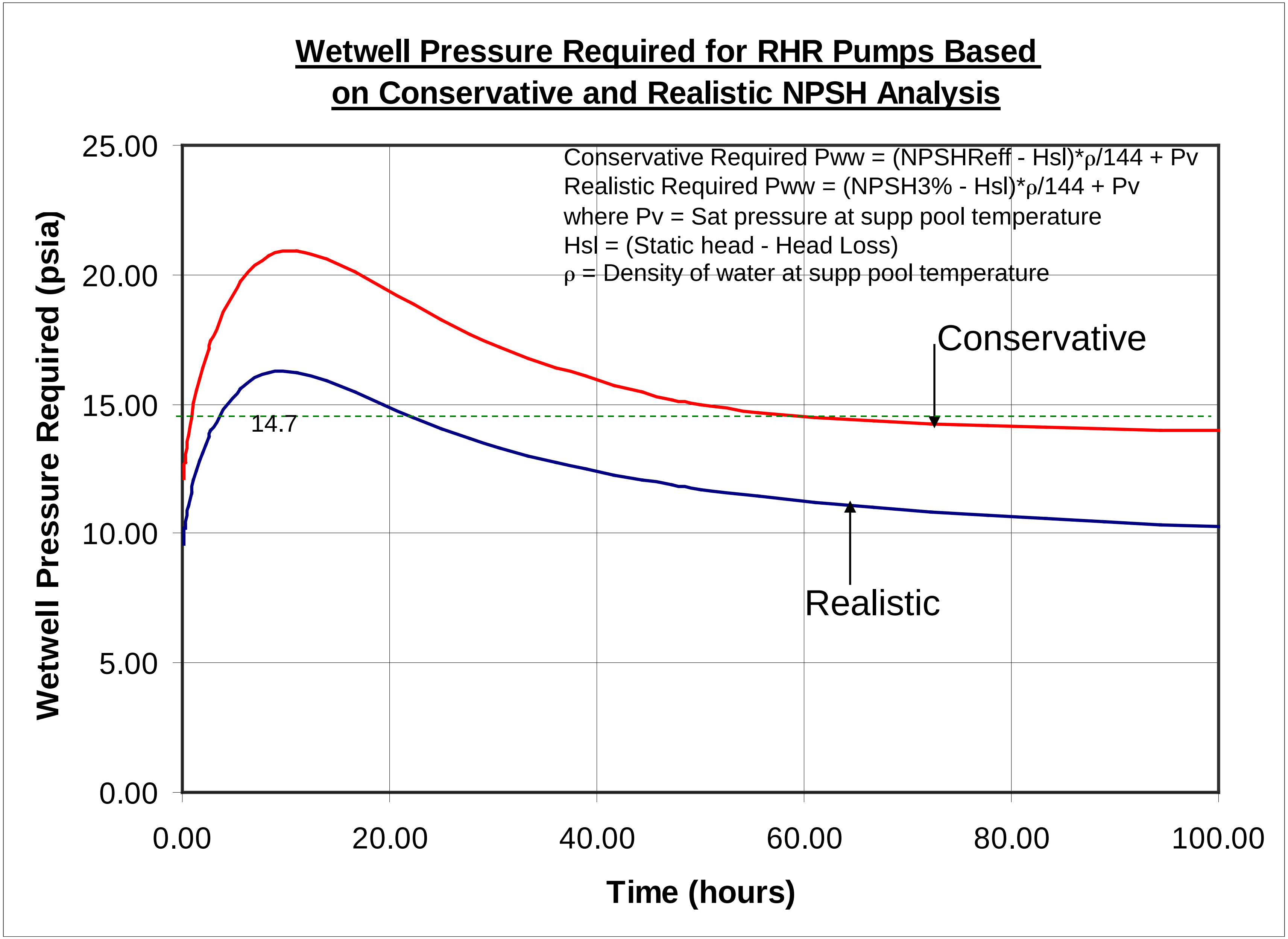
BWR-4 MARK I CONTAINMENT LONG TERM LOCA NPSH ANALYSIS SENSITIVITY STUDY RESULTS SUMMARY

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% = 26.62 ft
NPSHR3%= 22 ft
NPSH (ft)
Time (hours)
60.00
50.00
40.00
30.00
20.00
0.00
20.00
40.00
60.00
80.00
100.00

NPSHA Quantification

- Staff calculations for BWR/4 with Mark I containment show that the conservative calculation is approximately equal to statistical minimum (95/95).
  - This provides an approximate quantification of the conservative calculation.
- Staff calculation shows that realistic calculation approximately equal to the statistical mean.
  - This provides an approximate quantification of the realistic calculation.


Wetwell Pressure Required for RHR Pumps Based
on Conservative and Realistic NPSH Analysis
Conservative Required Pww = (NPSHReff - Hsl)*ρ/144 + Pv
Realistic Required Pww = (NPSH3% - Hsl)*ρ/144 + Pv
where Pv = Sat pressure at supp pool temperature
Hsl = (Static head - Head Loss)
ρ = Density of water at supp pool temperature
Conservative
Realistic
14.7
25.00
20.00
15.00
10.00
5.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
Wetwell Pressure Required (psia)
Time (hours)

Conclusions from NPSHA Calculations

- The realistic NPSHA calculation agrees closely with the statistical mean calculation of NPSHA
- The conservative calculation agrees closely with the Monte Carlo lower tolerance limit (95/95) calculation
- Staff guidance states that a realistic calculation of NPSHA should be performed and compared with either the conservative or Monte Carlo lower tolerance limit calculation to indicate margin in the NPSHA values.
- Staff guidance also states that the appropriate NPSH margin should be determined for each event for which containment accident pressure is used.
- Since margin is included in the conservative NPSHA calculation and $NPSHR_{eff}$ there is no recommendation of a margin between NPSHA and $NPSHR_{eff}$.

Comparison of Staff (GOTHIC) and GE (SHEX) calculations Typical BWR/4 Mark I

Parameter	GOTHIC	SHEX
Short Term Containment Pressure & Temperature Response Analysis		
Peak DW Pressure (psig) (LB LOCA analysis)	40.7	44.1
Peak DW Gas Temp (^oF) (SSLB analysis)	334	338
Long Term Suppression Pool Temperature Response Analysis		
Peak SP Bulk Temp (^oF) (LB LOCA Analysis)	199.5	203
Long Term NPSH Analysis		
Peak SP Bulk Temp (90^oF) (LB LOCA Analysis)	202.5	207.1

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)
  - NPSHA and NPSHR uncertainties quantified
  - Staff guidelines quantify margin
    - Between realistic and conservative NPSHA
    - Between NPSHA and NPSHR
- Quantitative guidelines are proposed
  - For LOCA: NPSH margin with uncertainty
    - demonstrates adequate pump performance
  - For non-LOCA events, NPSH margin without uncertainty demonstrates adequate pump performance
    - demonstrates adequate pump performance
    - consistent with current staff guidance for nondesign basis events