ACRST-3426

Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards
549th

Docket Number: (n/a)

Process Using ADAMS Template
ACRS/ACNW-005
SUNSI Review Complete
2/26/08

Location: Rockville, Maryland

Date: Friday, February 8, 2008

Work Order No.: NRC-2001

Pages 1-115

ORIGINAL

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1323 Rhode Island Avenue, N.W.
Washington, D.C. 20005
(202) 234-4433

TR04

DISCLAIMER

UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

February 8, 2008

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Reactor Safeguards, taken on February 8, 2008, as reported herein, is a record of the discussions recorded at the meeting held on the above date.

This transcript has not been reviewed, corrected and edited and it may contain inaccuracies.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

549TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARD

(ACRS)

+ + + + +

FRIDAY

FEBRUARY 8, 2008

+ + + + +

ROCKVILLE, MARYLAND

+ + + + +

The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Dr. William J. Shack, Chairman, presiding.

COMMITTEE MEMBERS:

WILLIAM J. SHACK, Chairman

MARIO V. BONACA, Vice Chairman

GEORGE E. APOSTOLAKIS, Member

DENNIS C. BLEY, Member

DANA A. POWERS, Member

JOHN W. STETKAR, Member

MICHAEL CORRADINI, Member

JOHN D. SIEBER, Member

COMMITTEE MEMBERS: (CONT.)

OTTO L. MAYNARD, Member

SAID ABDEL-KHALIK, Member at Large

J. SAM ARMIJO, Member

SANJOY BANERJEE, Member

TANNY SANTOS Jr., Designated Federal Official

STAFF PRESENT:

SAM DURAISWAMY

ZENA ABDULLAHI

A G E N D A

P R O C E E D I N G S

(8:30:27 a.m.)

CHAIRMAN SHACK: The meeting will now come to order. This is the second day of the 549th Meeting of the Advisory Committee on Reactor Safeguards. During today's meeting, the Committee will consider the following: Proposed BWR Owner's Group Topical Report on Methodology for Calculating Available Net Positive Suction Head for ECCS Pumps; future ACRS activities and report of the Planning and Procedures Subcommittee; reconciliation of ACRS comments and recommendations; Subcommittee report regarding draft NUREG 1855, Guidance on the Treatment of Uncertainties associates with PRAs and risk-informed decision making; a draft ACRS report on the NRC Safety Research Program, and the preparation of ACRS reports.

The portion of the session related to the BWR Owner's Group Topical Report will be closed to discuss and protect information that is proprietary to the Owner's Group and their contractors.

This meeting is being conducted in accord with the provisions of the Federal Advisory Committee Act. Mr. Tanny Santos is the Designated Federal Official for the initial portion of the meeting.

We have received no written comments or

requests for time to make oral statements from members of the public regarding today's session. A transcript of a portion of the meeting is being kept, and it is requested that the speakers use one of the microphones, identify themselves, and speak with sufficient clarity and volume so they can be readily heard.

I'd also remind the members that we're scheduled to interview a potential candidate during lunch time today, so don't run too far.

You have another CD that was laid down near you with slides from the NGNP Subcommittee meeting for those members who weren't able to attend. You also have a letter that we wrote back in 1988 on gas cooled reactors, just in case we want to be consistent.

MEMBER STETKAR: I can get you more history if you want.

CHAIRMAN SHACK: And I would like to welcome a new ACRS staff member, Christina Antonescu is on a rotational assignment to the ACRS staff. She has over 22 years of professional engineering experience in nuclear power. She has been a Project Manager in the Office of Nuclear Regulatory Research for 17 years. She has been working in the

Instrumentation and Controls area for over 15 years, and has investigative research experience involving digital INC technology and advanced reactor designs, including advanced light water reactors, such as ABWR, AP 600, and System 80 Plus.

Christina has a Bachelor of Science degree in Electrical Engineering, and a Master of Science degree in Telecommunications Management from the University of Maryland. Welcome aboard.

(Applause.)

MEMBER APOSTOLAKIS: You can speak now.

CHAIRMAN SHACK: Our first topic today is the BWR Owner's Group Topical Report on Net Positive Suction Head, and Said will be leading us through that.

MEMBER ABDEL-KHALIK: Thank you, Mr. Chairman.

Credit for containment over-pressure and calculating the available net positive suction head for ECCS pumps during an accident is, and has been, an issue of concern. To address some of the concerns raised by the ACRS with regard to this issue, the BWR Owner's Group formed a committee to develop guidance for NRC approval of such credit, and a method for quantifying the uncertainties in NPSH calculations.

Today we will be briefed on these activities. A Licensing Topical Report describing the methodology will be submitted in the near future. And, hopefully, we will have an opportunity to review that document.

Today's presentation will begin with the Staff's brief presentation, and that will be given by Mr. Lobel.

MR. LOBEL: Good morning. My name is Richard Lobel. I'm a Senior Reactor Systems Engineer in the Office of Nuclear Reactor Regulation. At today's meeting, the BWR Owner's Group, as you just heard, will present to the Committee a description of a statistical method to determine the available net positive suction head of BWR ECCS pumps.

The purpose of the method is to both reduce and quantify the conservatism in these calculations. We believe that at least in some cases that the need for crediting containment over-pressure is due to the conservatism of the calculations, and not the physical design of the plant itself. The emphasis in these cases is on crediting containment accident pressure in determining available net positive suction head, NPSH.

The NRC staff had proposed this approach as an option in a proposed revision to Reg Guide 1.82, which was previously presented to the Committee. The BWR Owner's Group used its technical expertise to convert this concept into a method described in the topical report that they plan to submit to the staff for review.

The BWR Owner's Group and the staff met in October of 2007 to discuss the method, and ACRS staff were present. Before the BWR Owner's Group makes its presentation, I thought it would be helpful to the Committee to introduce the subject by giving a very brief background on the history of the subject, the use of containment accident pressure in determining net positive suction head, and the regulatory guidance on the subject.

I'd like to start on page 4 of the slides.

CHAIRMAN SHACK: Just, Rich, let me ask; did the Rev. 4 ever become official?

MR. LOBEL: No.

CHAIRMAN SHACK: No.

MR. LOBEL: We never got passed ACRS.

CHAIRMAN SHACK: That was the 525th Meeting.

(Laughter.)

MR. LOBEL: We have plans to revise it. There are -- we're taking into account the recommendations of the Committee, informal recommendations of the Committee. As you were told at a previous meeting, we're planning to risk-inform the Reg Guide. We'll make the wording clearer, add more detail on determining NPSH, and maybe, depending on resources.

MS. BROWN: They asked me to sit next to you, and change your slides for you.

MR. LOBEL: Oh, thank you. If resources permit, do some other things, editorial nature to just make the guide easier to use.

Also, not part of my work, but there is some work going on in research to revise the same Reg Guide for GSI 191 issues. And whether those things will all get done at the same time, I'm not sure, but let me get back to the subject.

PARTICIPANT: Three will work.

MR. LOBEL: Three, yes.

MEMBER APOSTOLAKIS: Our 4 is your 3.

MR. LOBEL: Okay. Let me just use this little figure to illustrate what I'm talking about. I'm sure everybody has a basic idea, or even more, but just so everybody's on the same page with what I'm discussing.

Imagine a pump taking suction from a tank.

The available NPSH is determined by a simple formula that the pressure forcing the fluid into the pump minus the vapor pressure is, roughly speaking, what net positive suction is. And that's determined by a positive term for the atmosphere above the liquid surface, the static height of the liquid minus the loss flow loses of the liquid flowing from the tank to the pump, and it's done in terms of being above the vapor pressure, so there's a minus head for the vapor pressure. If this tank is open to the atmosphere, then H atmosphere is just a head of atmospheric pressure. If the tank is closed, H atmosphere can be above or below atmospheric pressure.

Imagine now this tank is the TOROS of a BWR with a suppression pool that fills a large part of the volume, and then gas above the surface of the water. One way of doing the NPSH calculation is just to assume that the pressure is atmospheric pressure. And if that doesn't give enough -- sufficient available NPSH, then credit is taken in some cases for the atmospheric pressure above the liquid being the accident pressure for whatever accident we're talking about.

MEMBER CORRADINI: And, if I just -- and when you do give this credit, then that becomes dynamic; that is, it changes with time.

MR. LOBEL: Right.

MEMBER CORRADINI: Okay.

MR. LOBEL: Right. Because the conditions change with time, the temperature of the suppression pool and the accident pressure change with time, and maybe even the flow rates change with time. Okay? Oh, I'm sorry. Do your job for you.

(Laughter.)

MR. LOBEL: It's hard to un-train me once I get started.

Okay. Some early reactors were licensed with crediting containment and accident pressure for NPSH. In 1970, the NRC issued a Regulatory Guide, which stated that no credit for increase in containment accident pressure should be credited for calculating NPSH.

In 1974, the staff issued a Regulatory Guide, 1.82, Revision 0, that talked about pump suction issues. And one of the criteria was that the blockage of the sump screen or the ECCS strainer in a BWR should be assumed to be blocked by 50 percent of its area. And that was the first official guidance in the area of sump blockage, or strainer blockage.

In the late 1970s, an unresolved safety

issue, USI A-43 was started, and in 1985 it was completed and a generic letter, and some NUREG reports were issued, and Regulatory Guide 1.82 was revised to Revision 1. And the results of this work were studies in debris blockage, air entrainment, sump design, and NPSH, but there was no change to the guidance of Reg Guide 1.1, as a result of this early work.

Next slide. In 1992, there was an event at a Swedish reactor where a strainer was blocked by debris, and this started a new look at the issue of blockage of strainers for BWRs. In 1996, this resulted in issuing a Bulletin 96-03, and another revision to Reg Guide 1.82, Revision 2 to the Reg Guide. This resulted in BWRs installing large paths of strainers to accommodate the change in assumptions from the 50 percent blockage criterion, to something more physically real. And it was based on the fact that not only was there this event in Sweden, but there were some events in the United States where strainers were actually clogged at BWRs.

About the same time, the staff became aware of some events at reactors that put into question the net positive suction head determinations at operating plants, and the staff issued a Generic Letter, 97-04, in 1997 that requested information on how licensees were calculating net positive suction head. And as a result of this, licensees went back and looked at their analyses and their determination, and some found that they had errors in the calculations, some found that things they were crediting weren't quite correct, some licensees couldn't find their analyses and did a reconstitution, and came up with new analyses. And a result of both the Bulletin 96-03, and the Generic Letter, some licensees found that when they put in the larger strainers, or when they went back and did their net positive suction head calculations, they didn't have adequate available NPSH, unless they credited containment accident pressure.

The staff reviewed the responses to the Generic Letter, and wrote letters back to licensees, and in cases where containment accident pressure was credited, especially, the reviews were pretty detailed, and got into a lot of the details of the calculations.

In 2001, about that time, the staff went to look at the PWRs, pressurized water reactors, as part of GSI-191, and issued another revision to Reg Guide 1.82, which became Revision 3. In this Reg Guide, although it wasn't really the focus of the Reg

Guide, the focus was the GSI-191 issues, the staff put in some guidance on NPSH. That was the first time that NPSH guidance had been put into the Reg Guide. And the purpose of that was to document the criteria that the staff had used in reviewing the Generic Letter 97-04 responses, because it wasn't all documented in any one place. You could find individual criteria in individual SERs, or letters that the staff wrote, but it wasn't all together. So the idea of putting it in Reg Guide 1.82 was to consolidate all the pump suction guidance into one Reg Guide, and that's the situation now.

The NPSH guidance, along with the other changes were presented to ACRS, but, like I said, I think the GSI-191 work really got the emphasis, and I don't know how much review, I don't think a whole lot of review was put on the NPSH guidance at that time.

Essentially, the guidance for NPSH, and this has been much criticized, and this is one of the things that we'll revise, but the guidance was that no credit should be taken for containment accident pressure, but it recognized a real situation, that in some cases it would be acceptable for operating reactors to credit containment accident pressure when there was no practicable alternative.

The staff position has been that credit for containment accident pressure would be allowed when the analyses, conservative analyses demonstrated that sufficient pressure was available for the design-basis accidents, and for beyond design-basis accidents an acceptable level of safety is maintained, and that means looking at this from a risk point of view, and looking at some of the events that are called special events, like Appendix R, station blackout, and ATWS, that aren't design-basis events, but that licensees analyze.

MEMBER CORRADINI: So can I make sure -- can you restate one a different way, so I understand what one means. I think I understand two based on what you just said.

MR. LOBEL: If there's no practical alternative, you can credit containment accident pressure if you determine the containment pressure available in a conservative way; which means you minimize the available pressure.

For some containment analyses, you maximize the pressure, like for peak pressure calculations to see if the containment is designed properly. In this case, you bias the calculation in the other direction, and you try to minimize in a conservative way the pressure that's available. Then you determine the pressure that you need, and the pressure that you need has to be below that conservatively calculated pressure that's available.

MEMBER STETKAR: Does that process of conservatively minimizing the pressure account for the fact that the operators are trained to do everything possible to keep pressure as low as practical, as low as possible?

MR. LOBEL: Yes.

MEMBER STETKAR: Manually initiating sprays, vents, whatever they have available?

MR. LOBEL: The calculations are done for BWRs, assuming that the sprays are on for the whole time that the transient. After 10 minutes, there's a 10-minute window at the beginning of the accident where no operator action is allowed. The assumption is that --

MEMBER STETKAR: Well, in the real world, operators do things in 10 minutes, though.

MR. LOBEL: In the real world, yes. Actually, I've discussed this with some operators, and in the real world, they would probably take action before the 10 minutes.

MEMBER STETKAR: Oh, absolutely.

MR. LOBEL: But the analysis assumes that the operator takes no action for 10 minutes. And then the operator starts the sprays, and the sprays stay on for the rest of the accident, so that's one assumption.

MEMBER BLEY: It's conservative when you're doing other kinds of calculations, you leave the operator out of the picture. But here --

MEMBER STETKAR: If they started in 30 seconds--

MEMBER BLEY: -- unless they start automatically, which I heard some --

MEMBER STETKAR: Sometimes they do, but if the operator starts it at T=30 seconds, assuming they wait for 10 minutes, is optimistic, isn't it?

MR. LOBEL: Well, the sooner the operator starts, the sooner he starts cooling the suppression pool. And it's the suppression pool temperature that's the key variable in all this.

MEMBER CORRADINI: So I guess I wanted to get back to that. Can you go back two slides, or whatever it is, the simple cartoon. So in the simple cartoon, HVP is a function of the water temperature.

MR. LOBEL: Right.

MEMBER CORRADINI: So when you say

"minimize", you also then are looking for the highest vapor pressure.

MR. LOBEL: Right.

MEMBER CORRADINI: Okay. You're not inconsistently --

MR. LOBEL: The calculations are done to maximize the suppression pool temperature, and minimize the containment pressure.

MEMBER CORRADINI: Okay. Thank you. Because the operators have different guidance regarding drywell pressure and suppression pool temperature. They're not trained to start suppression pool cooling until temperature in the suppression pool reaches -- which is a delay.

MR. LOBEL: Well, it turns out that crediting this really doesn't change the emergency operating procedures at all. The operator already has guidance, the EOPs already have guidance for the operator to make sure that he has adequate NPSH. There are some curves in the emergency operating procedures in terms of flow and temperature, suppression pool temperature and accident pressure to guide the operator, and those don't change. There could be a note put in to tell the operator that he needs to maintain the pressure at a higher value to make sure that he doesn't lower the pressure below the pressure that's credited.

MEMBER STETKAR: Well, having been an operator, and gone through exercises of when to trip reactor coolant pumps on pressurized water reactors, and when not to trip reactor - that type of guidance about keep pressure high under these conditions, and keep pressure low under other conditions can be a little difficult for operators to really follow.

My question was more not organized toward the emergency operating procedures, as to what conditions the staff will accept in the confirmatory analyses for the NPSH calculations.

MR. LOBEL: The calculations have been done in a very conservative way that, like I say, maximizes the suppression pool temperature, which is the key variable, and minimizes the pressure, so the sprays are on, but there are other assumptions that assure that the suppression pool temperature is at its maximum. You assume a maximum power decay heat, the level of the suppression pool is assumed to be at a minimum value, the pump flows that contribute to NPSH, the loss are assumed to be higher than expected, that kind of thing.

VICE CHAIR BONACA: I would like to say

one thing. I think we need to keep in mind that, for example, in the Brown's Ferry analysis of the Appendix R scenario, the containment cooling is switched off to maximize pressure in containment, so there are instances already we should keep in mind, that may be, in fact, counterintuitive for the operator.

MR. LOBEL: The drywell coolers are switched off. The suppression pool is still cooled. Could I suggest, this is taking longer than I expected. I'd be glad to come back and run through this with the Committee any time the Committee would like, but I'd like to give as much time as possible to the Owner's Group.

CHAIRMAN SHACK: Thank you. Proceed.

MR. LOBEL: So let me just finish up.

At present, there's 18 BWRs crediting containment accident pressure to some degree, and 10 PWRs, and that includes 5 sub-atmospheric containment PWRs that require it really as part of their design since they're at a low pressure, and the pumps start earlier, and that kind of thing.

The other point I wanted to make is that this gets treated, this issue gets treated a lot like it's something unique, and it's not really that unique. 10 CFR 50.46, which is the ECCS Rule, credits containment accident pressure in the sense that containment accident pressure is needed during the re-flood phase to assure proper re-flooding of the vessel, especially for PWRs. But implicit in that is the fact that there is a containment accident pressure that's assumed, and that's specified in Appendix K of 10 CFR 50.

Also, dose calculations are done, assuming the leakage is at ELSIV A which is less than a 1 percent mass leakage in 24 hours. That also assumes that all that other stuff is kept in the reactor, so the reactor's containment integrity is assumed, and the pressure is maintained. Although you're trying to lower the pressure, the dose calculations are done assuming a very small leak rate.

ATWS, station blackout, Appendix R events have acceptance criteria that require a demonstration of containment integrity as part of doing a satisfactory acceptable analysis.

And, finally, some of the reasons we've accepted the credit are a high confidence in containment integrity, conservative calculations, the design of the emergency pumps, no significant impact on emergency operating procedures, and minimal impact on risk. And if I could now, I'd like to --

MEMBER APOSTOLAKIS: So let me understand something. In an earlier slide, you said this minus 6, I don't know what one is that, 7? Could we go back. Yes, for beyond design-basis accidents and acceptable level -- so, in other words, does that mean that depending on the frequency of the accident, you may decide yes, they don't have sufficient pressure, but it's of such low probability that safety is maintained. Is that --

MR. LOBEL: Right. We -- Marty Stutsky has talked about this.

MEMBER APOSTOLAKIS: Right.

MR. LOBEL: We go back to the -- well, the licensee goes back to their PRA, puts assumptions in that are a function of containment accident pressure, and then looks at the probability of losing containment accident pressure. And then, like I say, the other part of this is the beyond design-basis events that are typically analyzed, Appendix R, ATWS, and the station blackout. They're analyzed to see that there's acceptable results.

MEMBER APOSTOLAKIS: Right.

MEMBER POWERS: When you say they go back to their PRA, you are, of course, speaking of a PRA that includes fire as an initiator, seismic as an initiator?

MR. LOBEL: Sometimes fire is included. My understanding is in some cases fire isn't included, and the review is done looking at the Appendix R program separately. But they do look at sets that involve containment pressure, and put -- make sure that consideration is given to the loss of containment pressure, and the effect that has on the ECCS.

MEMBER POWERS: Thank you.

MR. LOBEL: I'd like now to introduce Mr. Randy Blunt of the BWR Owner's Group to get on with the main part of this presentation.

MEMBER ABDEL-KHALIK: My understanding is that you have some backup slides that may have some proprietary information. And if questions come about that require you to show these slides, that we will have to wait until the closed session at the end of this period.

MR. BLUNT: That is correct.

MEMBER ABDEL-KHALIK: Okay. Thank you.

MR. BLUNT: Verify the question, write it down so we'll get it covered properly when we go back to that.

MEMBER ABDEL-KHALIK: Yes.

MR. BLUNT: Well, I appreciate the

opportunity to come here. This is a topic that we're very pleased to work with NRC on that came up as an issue from the ACRS, and we formed a committee going forward, and we believe this is an area that we're working together to improve the industry. We do have our committee experience and technical experts here to address questions and concerns. And our Committee Chair, Alan, here, who's going to go over this in detail with his presentation. I just wanted to open it by saying we do appreciate the opportunity to present our topical here. Thank you. Alan.

MR. WOJCHOUSKI: Thank you. Good morning everybody. My name is Alan Wojchouski. I work at Monticello Nuclear Generating Plant. I have an Undergraduate degree in Mathematics, Physics, and Computer Science minor, and picked up a Master's degree in Nuclear Engineering from VPI. I worked at Exxon Nuclear for several years doing neutronics for Perry Island Units I and II. Then I moved to Monticello, worked at Monticello Nuclear Generating Plant for the last 28 years. Currently, I'm the System Engineer on primary containment and RHR. So with that, I'll start into my presentation.

The purpose of the presentation is to provide background, objectives, and work scope, provide an overview of the licensing topical report, to describe how the licensing topical report addresses the ACRS' concerns with granting containment over-pressure credit.

Late in 2005, the BWR Owner's Group was requested to provide information that could be used by the staff to address ACRS issues with approval of containment over-pressure credit. The Committee that I'm the Chairman of was approved by the Owner's Group Executives in May of 2006.

The BWR Owner's Group main objective was to develop guidance for NRC approval for credits for containment over-pressure where practical alternative approaches do not exist; conservatisms in the methodology. I'll discuss the safety implications, and define reasonable and consistent requirements and methodologies.

The key results from our work that will be explained in more detail as I progress through the presentation are that the DBA-LOCA, and special events, both the change in the core damage frequency, and the change in the large early release frequency fall within Reg Guide 1.174, a very small category of risk increase region. Deterministic approach, which is basically the current licensing basis approach, is a conservative assessment of the net positive suction head available.

MEMBER APOSTOLAKIS: What's the meaning of the first bullet? I guess I don't see it. "The change in CDF". This change is due to what? Maybe you said it, and I missed it.

MR. WOJCHOUSKI: The change in loss of containment over-pressure.

MEMBER CORRADINI: In other words, if somehow you magically fall to --

MR. WOJCHOUSKI: You go ahead and have no over-pressure except for atomospheric pressure. Underneath those conditions, what happens to your ECCS pumps? We did a risk assessment based on that, and compared it off to the Reg Guide requirements, and it was in the 10 to the minus 9^{th} region, which puts it into the very small category. I'll be getting into that a little bit further within the presentation. And if there's additional questions, I have more expertise here to help me out with those.

MEMBER POWERS: I mean, it's truthful and mysterious because the design-basis accident, I would expect the delta CDF associated with a DBA to be -- it's still very small. I mean, it's kind of meaningless, isn't it?

MR. WOJCHOUSKI: We still have to ahead and evaluate what granting containment over-pressure is in risk-based. That's the reason why the Reg Guide has different bands to go ahead and categorize it as whether it's medium risk, small risk. That's why we went ahead and did that type of evaluation.

MEMBER APOSTOLAKIS: 1.174 refers to permanent changes in the licensing basis. This is a permanent change?

MR. WOJCHOUSKI: If you're asking for containment over-pressure where you didn't have it before, it would be considered a permanent change. Some plants --

MEMBER APOSTOLAKIS: So we shouldn't worry about the conditional probability, incremental conditional probabilities that we calculate under other circumstances? Time, in other words, during the accident, because we have limits on those, too. It's probably too small.

MEMBER POWERS: It seems to me that what it says --

MEMBER APOSTOLAKIS: Huh?

MEMBER POWERS: It seems to me that the risk for the pump is very small, which is a remarkable conclusion.

CHAIRMAN SHACK: Let's let him get to --

MEMBER APOSTOLAKIS: Okay.

CHAIRMAN SHACK: I mean, he's got lots of slides.

MR. WOJCHOUSKI: Statistical approach, which is a realistic, demonstrates the margin inherent in the deterministic approach. Low pressure ECCS performance from the analysis that we conducted was shown not to be dependent on the containment integrity, and I'll go over that in more detail later. And pumps have been shown to survive periods of operation, the net positive suction head available is less than the net positive suction head --

MEMBER ARMIJO: For how long? Are you going to get into that? How long can these things run? Will you get into that later?

MR. WOJCHOUSKI: I will get into that to a certain extent.

MEMBER APOSTOLAKIS: Give us results first.

MR. WOJCHOUSKI: Okay. It's a style that was recommended to try to have you guys think about it as I go through the rest of the presentation.

MEMBER POWERS: We're thinking now, were we? But you're going to get to that.

MEMBER APOSTOLAKIS: Yes.

MR. WOJCHOUSKI: Yes. Okay. Work scope. The project work scope of the committee was to identify an example plant, that was Monticello Nuclear Generating Plant. Monticello is a Mark I containment, so we're one of the ones that have been granted in the past containment over-pressure credit; review of containment analysis inputs, and methods for conservatisms; perform a sensitivity study to assess the impact or the input parameters on the containment response. And then, also, we identified the input parameters for the example plant NPSH analysis. That could be changed to minimize or gain over-pressure credits.

MEMBER ABDEL-KHALIK: Now why and how was Monticello selected?

MR. WOJCHOUSKI: Monticello was selected because we were, basically, the next one up for EPU, Extended Power Uprate. So as you go ahead and increase your power, the containment analysis will have your suppression pool temperature start to elevate. As your suppression pool temperature goes up, guess what? Okay.

MR. BLUNT: Also, because some of the analysis that was being done as part of their power uprate, that would support some of the work was going to be performed at that time for the uprate, so it was the most current data that we had to report to the Committee without having to redo all the work.

MR. WOJCHOUSKI: We went ahead and performed containment analysis on the example plant deterministically using licensing-basis inputs, and also statistically using realistic inputs, and then compared the results. In order to do the statistical analysis, we had to develop a statistical methodology first in order to do that, and I'll be discussing that, also. Performed risk assessment using results of the realistic analysis, and assessed the effects of the credit on containment over-pressure for special events. So we didn't do actual calculations on the special events, but we went ahead and looked at those special events and did a risk assessment on those, also.

MEMBER MAYNARD: Back to the first bullet there. And if you're going to get into it later, that's fine, too, but you say develop method, licensing-basis inputs. Again, we were talking earlier licensing-basis inputs, there's times when you're wanting to maximize pressure, times when you're wanting to minimize pressure.

MR. WOJCHOUSKI: NPSH you want to minimize the pressure, and maximize the suppression pool temperature. I have a couple of slides that will kind of go through that and describe a little bit more detail, but if you've got a question after those, bring it up again.

MEMBER STETKAR: Alan, you said that for special events, Appendix R, station blackout, and ATWS, you did not run those through the risk assessment.

MR. WOJCHOUSKI: For the Committee we did not do that analysis, like Monte Carlo analysis, or deterministic calculations for the Committee work, but we did is in the risk assessment, went ahead and evaluated those in a general fashion with bounding numbers.

MEMBER STETKAR: I'm assuming you're going to get to that.

MR. WOJCHOUSKI: We will get to that.

MEMBER STETKAR: Okay.

MR. WOJCHOUSKI: And if you want actual more detail, we have a special breakout presentation that we can go through and go over that in more detail.

MEMBER ABDEL-KHALIK: Did you skip one?

MR. WOJCHOUSKI: I think I just went back, didn't I?

MEMBER ABDEL-KHALIK: No, you went forward. You want to go through 8.

MR. WOJCHOUSKI: Number 8. There we go. Thank you. The methodology employed is you calculate the net positive suction head available without containment over-pressure. This is done deterministically, basically, the same license-basis type assumptions we've had. Conservative assumptions are used on that, and then you determine the wetwell pressure so that NPSHa equals NPSHr.

MEMBER CORRADINI: And let me just repeat. Conservative here means maximize the suppression pool temperature, estimate with some sort of approved method the losses, so your two negative terms are as high as possible. As high as possible is wrong; as high as required by the methodology.

MR. WOJCHOUSKI: Correct. What you do in containment analysis is you pick your inputs into the containment analysis, such as maximum river temperature for ultimate heat sink, minimum TOROS water level so that you'll actually drive more heat into it, and for NPSH we have several different scenarios in which we minimize the containment pressure.

MEMBER CORRADINI: Okay. Thank you.

MEMBER BANERJEE: How expensive is it to change the pumps? I mean, let's look at our last - Susquehanna, they have pumps that don't require water pressure.

MR. WOJCHOUSKI: I can speak for Monticello. I can't speak for everybody else. We were a turnkey plant. We have RHR and core spray pumps in corner rooms in the basement. We have the bolts that hold them in place go four feet down into rebar and the concrete sub-basement, and there's approximately 12 feet of concrete and rebar underneath it. If we went ahead and tried to put in deep well pumps, like we have on RHR service water, we would have to go and excavate all of that underneath.

MEMBER BANERJEE: So it's just an accident of history you're stuck with this. Now you want to uprate, you want to sharpen your pencil to make sure you can make it work.

MEMBER MAYNARD: It could also create more problems than what you solve. Some of these situations, you could create a bigger problem by digging down deeper and doing things in your containment, than leaving the pumps that are there, and using legitimate credit that's available.

MEMBER BLEY: These are pretty rugged pumps, none of the problems --

MEMBER SIEBER: You give credit for operation below the manufacturer's required NPSH, generally, and also for limited periods of time. Allows you to ride through some --

MEMBER MAYNARD: But, typically, you don't like to be putting bigger holes in containment and base mat and stuff than what you would have to.

MEMBER BANERJEE: Well, I was wondering whether you could change these pumps without having to do that.

MEMBER SIEBER: By magic.

MR. WOJCHOUSKI: There really isn't a design that I know of. That's why it's not a credible --

MEMBER MAYNARD: You typically maybe get a little bit, but to get any significant improvement, you end up having to go with a deeper draft pump.

MEMBER SIEBER: Well, these aren't deep draft pumps, are they?

MR. WOJCHOUSKI: No.

MEMBER SIEBER: They're horizontal.

MR. WOJCHOUSKI: Not these.

MEMBER MAYNARD: Not these.

MR. WOJCHOUSKI: The ones I have is vertical.

MEMBER SIEBER: PWRs are deep draft, some of them.

MEMBER BANERJEE: Please continue.

MR. WOJCHOUSKI: Moving on. If the NPSHa without containment over-pressure is lower than the NPSH required, you insure that you have enough wetwell pressure so that the NPSHa with containment over-pressure is higher than the NPSH required. You evaluate statistically, this is a Monte Carlo-type of arrangement, which I'll discuss.

This provides a realistic evaluation of the events in support of the containment over-pressure request based upon the deterministic calculations. What I'm trying to say with that bullet is, we are still going to license with the deterministic calculations, and we're going to do the statistical methodology to show you what the margin is of realistic calculations rather than piling on all the conservatives that you do with the deterministic. I'll have examples of that that you can see the differences between the two.

NPSH overview. The available net positive suction head can be expressed with the following equation. This is just a rewrite of what you've already seen before. We got the wetwell air pressure, minus the vapor pressure, times 144 over the density, minus your pool elevation, minus your pump elevation, minus your suction strainer and line losses.

MEMBER CORRADINI: Since you put numbers in there, this is in feet?

MR. WOJCHOUSKI: This is all in feet.

MEMBER CORRADINI: Thank you.

MR. WOJCHOUSKI: Go ahead --

MEMBER BANERJEE: Psia.

MR. WOJCHOUSKI: Yes.

MEMBER BANERJEE: Mixed units.

MEMBER CORRADINI: The left-hand side.

MEMBER STETKAR: The answer is feet.

MR. WOJCHOUSKI: When we converted over to Hww, that's in feet. And what we've done on here is there's two terms that we kind of ahead for our analysis here, we call it Hww, which is a term which we can get out of the containment analysis, and which General Electric does a containment analysis for us, and they come up with that term. The HPL is basically the suction strainer and the suction line losses that the utilities typically will go ahead and calculate, and by adding those two factors together, then you come up with your NPSH available. So it's a little different, but it's the same basic equation.

Deterministic approach, current licensing-basis accident scenarios with applicable limiting single failures are used in the determination of net positive suction head, bounding values of the containment initial conditions are used resulting in the pool temperature response. It is maximized when the available wetwell pressure is minimized. This approach will give you a conservative assessment of your available net positive suction head.

MEMBER ABDEL-KHALIK: Are you going to provide a list of the assumptions that allow you to obtain this conservative result?

MR. WOJCHOUSKI: The details of that are within the license topical report. We have it, it's there, and it's available. I didn't put it into the slide. I do have slides on here that says what we went ahead and used statistically varied, and which are basically the same ones. We'll get to that, and you can see a list of those.

MEMBER CORRADINI: Can I ask a different question?

MR. WOJCHOUSKI: Sure.

MEMBER CORRADINI: So back when you have NPSHr, that's a manufacturer's number?

MR. WOJCHOUSKI: NPSHr is provided by the pump manufacturer.

MEMBER CORRADINI: Under what conditions? I mean, where in the pump curve? I mean, are they looking at full run out? Where are the --

MR. WOJCHOUSKI: You will do it at different pump flow rates. The story behind this is on my ventures with plants, they went ahead and give you something; Bingham Pump Company gave you something called a sales curve.

MEMBER CORRADINI: Right.

MR. WOJCHOUSKI: What they did is theoretically calculated what the NPSH was over the flow rates of interest, 3,000 to 4,500 gpm for our type of pumps. When they sold you the pumps, they went ahead and took those into the test stand. They'd verify that they had at least that much NPSHr, so that was taken care of. But the problem was that isn't the standard net positive suction head required curve of 3 percent total dynamic head drop. That's what in the standard. That pump manufacturer will put it in a test rig, same type of diagram which Rich had up there, where he had the tank. They will go ahead and actually pull a vacuum on it to reduce the suction pressure on it until they start getting cavitation, in which they do it first of all with adequate NPSH, lots of volume on it, lots of over-pressure, find out what the total dynamic head of the pump is. Then they'll go ahead and reduce it until they get a 3 percent drop in total dynamic head at that flow rate and take that point. They'll change the flow rate, do the same thing, so 3 percent they have another point on that curve, and they will continue that through the range of the -- and that's how you get your NPSH 3 percent curve.

They can also, if you ask them to, and they have the data for it, they can generate a 5 percent curve, also. But the standard is a 3 percent curve total dynamic head.

MEMBER CORRADINI: And that's what you use as the NPSHr.

MR. WOJCHOUSKI: That what we go ahead and put into our calculations on NPSHr. Monticello, prior to this EPU did not have a curve, a 3 percent curve for RHR. We use the sales curve, which was conservative. So, in actuality, by me going out to a pump manufacturer and asking him for a 3 percent curve to the standard, I provide myself by reducing the margin in that area, provide myself more net positive suction head available.

MEMBER CORRADINI: So you don't have it for your pumps. But when -- I just wanted to ask it, because you use the -- I want to say it back to you so I get it right.

MR. WOJCHOUSKI: Okay.

MEMBER CORRADINI: Which is the NPSHr could be represented by the endpoint sets required in the pump curve as delivered, but then you can come back and do a bench test to see what the -- based on 3 percent, and it tends to fall below that.

MR. WOJCHOUSKI: Right.

MEMBER CORRADINI: So for some pump manufacturer, what's that variation? What's the difference there?

MR. WOJCHOUSKI: It depends on the pump design. And they have to go in and find test cases which they've run in the past.

MEMBER CORRADINI: To compare.

MR. WOJCHOUSKI: To compare, and come up with those curves. A lot of times they can use the data they originally had from your sales curve, and they have to add additional data.

MEMBER CORRADINI: Are we talking inches

or feet?

MR. WOJCHOUSKI: We're talking feet.

MEMBER BANERJEE: They test some, or they have data on some equivalent pump?

MR. WOJCHOUSKI: Right.

MEMBER BANERJEE: But not your pump, because it's --

MR. WOJCHOUSKI: Our pump was from the sales curve which they actually had. Then they do comparisons to identical pumps that they have in their archives, because they did all this sort of testing back in 1968. Kind of a side on this, I asked them if I wanted to go ahead and have a pump built, and have it tested, to get nice curves in your data, I asked one of their engineers, and off the top of his head he said, "Well, it would probably cost you $1 million to get it to upset our production rate, and then we have approximately a year delay on our test facility for testing the pumps, because we have so much business in oil business right now." I asked the question. I was feeling it out, seeing what was happening.

MEMBER BANERJEE: So your pumps were tested back in 1968, the identical pumps.

MR. WOJCHOUSKI: My pumps were tested in 1968.

MEMBER BANERJEE: What is the sort of variability in the results that you get, sort of like between --

MR. WOJCHOUSKI: We had four different pumps, we had four different serial numbers, we had four unique tests done on that. The variability was underneath a foot, usually about, from my recollection of them at the different points is about a half a foot or less.

MEMBER ARMIJO: I don't know anything about pumps, but over a long period of time with maintenance and operation, and everything else, how much --

MR. WOJCHOUSKI: Degradation of the pump?

MEMBER ARMIJO: -- does it change? Yes.

MR. WOJCHOUSKI: Performance? We have -- I'm getting off the subject again, but I'll answer the question quickly and then move on.

MEMBER ARMIJO: You don't have to spend a lot of time. Just --

MR. WOJCHOUSKI: We an in-service testing program in which we go ahead and have set up limits of the pump DT. That indicates how well the pump is performing, so we have acceptance bounds like that. I trend those. If I see a negative trend on it, I will go ahead and replace the rotating element on the pump and rebuild it with wear rings. We've done that several times, so we try to maintain it.

MEMBER SIEBER: Generally, the wear is on the outer side of the pump.

MR. WOJCHOUSKI: There's replaceable wear rings that --

MEMBER SIEBER: You're leaking backwards, which really doesn't change NPSH.

MEMBER BANERJEE: So these are -- there's a volume in these pumps. The volume does not affect it, it's only the impeller that gets affected?

MEMBER SIEBER: Well, there's replaceable rings.

MR. WOJCHOUSKI: Replaceable rings both on the casing of the pump, and on the impeller.

MEMBER SIEBER: Right.

MR. WOJCHOUSKI: Moving on. Statistical approach takes credit for variabilities in the analysis input values, the order statistic method is employed, input variabilities are defined statistically and combined through the Monte Carlo process. Fifty-nine random draws are made from the corresponding probability distributions to achieve a 95-95 probability confidence level. Containment pressure and temperature time histories are calculated for each of the 59 cases.

MEMBER STETKAR: Alan, what are the typical ranges on these input variables? I mean, are we talking about -- you said you have probability distributions for each input variable. Are we talking about a factor of five between the fifth and the 95th percentile of the input? Are we talking about a factor of 100, or 2?

MR. WOJCHOUSKI: Let me give you an example, and maybe we can answer your question that way. One of the inputs that we use for this analysis was river water temperature. That's your ultimate heat sink temperature. What I did at Monticello is I went and took five years of back data every four hours, and then came up and bend them into different bends, from 90 degrees, to 85 degrees, from 85 to 80, and going down, and then calculating how many days that I actually hit over those five years. And then you can have an exceedance probability that's generated off of that. That's one of the inputs, they have the exceedance probability on those temperature ranges. They do a random selection of it, pulls out one of those ranges, and that's what that one variable input is into one of the 90, or the 59 cases.

MEMBER STETKAR: How many bins did you typically have in these discrete distributions? Fifty-nine samples is a strange number. That implies to me that somebody really thought about optimizing this Monte Carlo process. I mean, typically you would do hundreds, if not thousands of samples to get a decent distribution.

MEMBER SIEBER: Fifty-nine pops up a lot.

MEMBER STETKAR: It depends on the range of your input curve.

MEMBER POWERS: He picked fifty-nine because that gives him the 95 percent confidence that he sampled 95 percent of the range.

MR. WOJCHOUSKI: That's out of the order statistic methodology. It has an equation that tells you how to do that, and how many you should really pick. And fifty-nine, I believe, is the minimum to get the 95.

CHAIRMAN SHACK: It is the minimum, yes.

MEMBER ABDEL-KHALIK: There is a time difference there in this process, and that's what I'm having difficulty with. When you say 95-95, you can say that, in words, that the containment pressure -- we're 95 percent confident that in 95 percent of the cases that containment pressure will be greater than this value. Where does the time dependence come in into this sort of wording of the result?

MR. DENNIG: Excuse me. This is Bob Dennig, Chief of Containment Branch. Don't you -- you use the sampling as the starting point, and then run the case.

MEMBER SIEBER: Right.

MR. DENNIG: Right. So there's no more imposed, externally imposed or extrinsic time management that goes on. The case is just you select that value and run that case to the end. Another random set, those inputs run that case to the end.

MR. WOJCHOUSKI: And it's the number of cases that give you the 95-95. We've got a --

MR. BOLGER: This is Fran Bolger from GE Hitachi. When we evaluate the data, we process the output at each of our time increments, so we actually will calculate a 95-95 at discrete time increments throughout the event so that we can establish what the minimum margin is at all time increments.

MEMBER ABDEL-KHALIK: So the 95-95 value that you have, many different values that come from --

(Simultaneous speech.)

MR. BOLGER: That is correct.

MEMBER ABDEL-KHALIK: Okay. Thank you.

MEMBER BANERJEE: So the model that you use is frozen for these 59 runs?

MR. BOLGER: I'm not --

MEMBER BANERJEE: It's just the inputs that are changing.

MR. BOLGER: That's correct, the model is the same.

MEMBER BANERJEE: None of the model parameters are changing.

MR. BOLGER: Well, there are model parameters that are part of the sampling. For example, decay heat would be considered a model parameter, and that's one of the items that's --

MEMBER BANERJEE: In fact, it's an input in this.

MR. BOLGER: That is correct, it is an input.

MEMBER BANERJEE: You're only changing the inputs.

MR. BOLGER: That is correct.

MEMBER ABDEL-KHALIK: So you're essentially drawing a limit curve that bounds all the time histories of the containment pressure, just to align underneath all of those 59 transients.

MR. BOLGER: That's correct.

MEMBER BANERJEE: It's a sensitivity to inputs, if I understand. But what about the model parameter --

MEMBER CORRADINI: But, normally, my impression from a lot of this is the uncertainties -- I mean, the initial conditions they're talking about drive the uncertainty, as I understand.

MEMBER BANERJEE: I know that. I'm asking the question. Do they drive the uncertainties, or do the model parameters which are built into the models drive the uncertainties?

MR. BOLGER: It's a combination of factors. For example, the decay heat is an important term in the uncertainty. But, also, the other input parameters regarding to the plant parameters are also very important.

MEMBER BANERJEE: But what about the model itself?

MR. BOLGER: There is no variation made on the model.

MEMBER BANERJEE: There must be parameters within the model.

MR. WOJCHOUSKI: Let me move on a little bit on here, and I'll show you what the different parameters are that we defined statistically, and are variable within --

MEMBER BANERJEE: We understand you're varying the inputs. I'm just now trying to understand what is in the model. What is in the model which is -- I'm --

MEMBER ABDEL-KHALIK: My understanding is the model that is being used in this is the SuperHex code.

MR. BOLGER: Essentially, that's correct. The SuperHex code is used.

MEMBER ABDEL-KHALIK: And that model, or that code has never been really approved the staff, has it?

MR. WOJCHOUSKI: That is the code which people do the deterministic calculations on, and it's been gone through the staff.

MEMBER ABDEL-KHALIK: But do we have a document that describes --

MR. LOBEL: This is Richard Lobel from the staff. The SuperHex codes have been used by GE for decades now. In 1993, the staff wrote a memo to GE saying that SuperHex was approved with the condition that benchmarks be done for every application, comparisons with FSAR results, that in a lot of cases were done with other codes. That was done for a while, and the results were always good, good comparisons.

As part of some extended power uprate reviews, the staff did independent calculations with the contained code to compare to SuperHex, and both curves fell practically right on top of each other, so we have done audits, and SuperHex has been used for a lot of different applications. And, although we never wrote an official SER, it's been the licensing code for a long time. And it's not that unusual for containment codes not to be approved by the staff. It's not like some of the systems codes and core codes, and that kind of thing. Typically, containment codes aren't approved by the staff.

MEMBER ABDEL-KHALIK: Thank you. Please proceed.

MEMBER BLEY: I'm sorry. Back to your 95-95, I'm thinking of the PRA implications of how you're doing the calculation. That tells me there's a 95 percent chance that 5 percent of the time the pressure is lower than this value you've calculated. Did you take that into your PRA results, five times 10 to the minus 2 chance that you don't meet NPSH?

MR. WOJCHOUSKI: Vince, would you help me out on this one?

MR. ANDERSEN: Yes, we did. And, actually, the number is higher than 5e to the minus 2, because the answer is actually lower than required. So we are somewhere up above the 5 percent point. So, yes, if the NPSHa, the 95-95 point that they got out, equaled what the NPSHr, as required, that would be perfect for the PRA. That would be the 5e to the minus 2 we've shove into the PRA, but it's not, so it's lower than it, so the number is higher. So it's 10 percent, 50 percent for two different scenarios that we get into the inadequate NPSH problem.

MEMBER BLEY: Will we see some details on that?

MR. ANDERSEN: Yes, we have slides on that, if you want to get into it. Yes, we have slides on that.

MEMBER BLEY: Okay.

MR. ANDERSEN: The actual number itself is not the driver in the risk, because we set that probability that you'll have the bad conditions at the onset of the accident to 1.0, and the risk is still low. What drives it are the low frequencies of the initiator, the low frequency of an unisolated containment, et cetera.

MEMBER BANERJEE: I do have a question on SuperHex. Is there an internal apportioning of where the heat actually goes that is somehow empirical within the code?

MR. BOLGER: This is Fran Bolger from GE, again. SuperHex is an integral model, and heat has to travel from the reactor vessel into the drywell. There's a pool model in the drywell. You have to get liquid transferring from that pool through the vents into the suppression pool. You have to have mass transfer between the pool and the vapor space.

Now as far as how is the heat transferred from the reactor vessel into the drywell, there's different types of techniques you can use to try to maximize the amount that goes into the liquid, which then goes into the suppression pool. When you're trying to minimize pressure, what you're trying to do is maximize the amount of cold liquid that is acting like a spray into the drywell, so that that will drop the pressure in the drywell, and that's what we try to do when we do the simulation.

MEMBER BANERJEE: You actually have an internal switch which can change how the heat is apportioned. You have to. There's no other way to do it.

MR. BOLGER: Well, we have -- for example, one of the things you can do is when you have liquid exiting through a break, you can establish, well, how much of that liquid should be considered in thermal equilibrium with the air space such that you would calculate the pressure in the air space. And then how much of that liquid would go directly -- can be considered to go directly into the pool, which then acts on the temperature of the pool.

MEMBER BANERJEE: These parameters are tuned to experiments?

MR. BOLGER: I think -- I don't have great expertise on this area. In the shorter portion of the event where there was test data, to some extent there is -- some of this apportionment is qualified. But as you continue into the longer term of the event, you attempt to set some of these inputs such that you set them conservatively. I would say that we did do some sensitivity analysis on some of these terms to determine whether or not there was a significant impact on the results, and we found that even if we made a fairly substantial change in this apportionment, that there was not a significant impact on the result.

MEMBER BANERJEE: That's useful to know.

Is that documented somewhere?

MEMBER ABDEL-KHALIK: Will the topical report include a description of the model in SuperHex code?

MR. BOLGER: No.

MEMBER BANERJEE: Because there are two sets of uncertainties here. One is related to the input parameters, the other is what is the internal parameters of these codes, so I think we need to understand the effect of uncertainties. And if you have already done this work, that would be useful to see.

MR. LOBEL: This is Richard Lobel from the staff. Let me just say quickly that one of the bases for starting this work when we were discussing it with GE and the Owner's Group was that SuperHex was assumed to be fixed, and it was used all the time, and so it wasn't going to be questioned for this. Its ability to do these calculations had been proved enough that it wasn't part of this project.

CHAIRMAN SHACK: Let me just ask again, though. I'm assuming that you're doing this in a design-basis sense, that whatever the input variable is, you're apportioning your heat input to maximize your pool temperature, and minimize your containment pressure for each set of those, so you're really doing a conservative calculation for each set of input variables, even though you're now realistically varying the input variables.

MR. BOLGER: That's correct.

MEMBER BANERJEE: Conservative can be two different things, because in a certain sense you're trying to maximize the pressure, and in another sense you might be trying to minimize it.

CHAIRMAN SHACK: But in these particular calculations he has a goal. When he does the other calculation to look at the containment over-pressure he sets it a different way. But, I mean, to look at uncertainties here, this is not a realistic code, so you're looking at sort of uncertainties in a deterministic analysis.

MEMBER BANERJEE: I'm trying to grapple with what you are really doing here.

MR. WOJCHOUSKI: Moving on. Statistical approach allows the calculation of more realistic net positive suction head available values, which can be used to quantify the conservatisms in the deterministic analysis. The design-basis LOCA approaches, you do the deterministic approach, which uses either the maximum or the minimum of each of the input parameters dependent on which direction is conservative for your analysis.

The statistical approach, all the input parameters are not at their extremes at the same time, so statistical approach with realistic assumptions that input the parameters that can be selected statistically are defined and selected.

MEMBER POWERS: How do you handle correlations?

MR. WOJCHOUSKI: Meaning independence of the input data?

MEMBER POWERS: Yes. I mean, you've got a set of statistically varied parameters here, some of which are manifestly correlated with each other. How do you handle correlations?

MR. WOJCHOUSKI: Within the selection thing, they put boundaries on it so that --

MEMBER POWERS: That's not what I'm asking. I'm asking how you handle correlations.

MEMBER BLEY: On the chance of one value changes the likelihood of another value?

MEMBER ARMIJO: Some things have to move together.

MR. WOJCHOUSKI: That's right. Some of them are interdependent on each other.

MEMBER ARMIJO: Yes, some are interdependent, some are correlated.

MR. WOJCHOUSKI: Well, for the interdependent stuff, what we went ahead and did is for drywell pressure, you cannot have your suppression pool pressure greater than the drywell pressure, because there are vacuum breakers. So as the pressure in the wetwell increases, it will relieve itself into the drywell.

MEMBER POWERS: What I'm asking you, you're going to go through and sample these things, and you've defined an uncertainty distribution for a parametric value. Some of the values will be correlated with each other. How did you tell the sampling, the Monte Carlo sampling that there was a correlation?

MR. WOJCHOUSKI: I'll have to ask for some help on that one.

MR. BOLGER: This is Fran Bolger of GE. In some cases, like Alan has stated, when the sampling was done, parameters were forced to follow each other where that was appropriate. For example, the pool temperature and the air space temperature were correlated together, so they were held together during the sampling process. Other things that were found to be independent with the data process, for example, the service water temperature and the initial pool temperature, which you might think would be correlated, which actually they were shown to be independent of each other, were sampled independently in the analysis.

MEMBER POWERS: I'm still not understanding. How did you set up your distribution so that the Monte Carlo sampling knew things were correlated? And you did not. I think you sampled them as though they were independent.

MEMBER STETKAR: Yes, let's ask them. If these are the variables that were sampled, is the assumption that they are all statistically independent? Was that assumption made?

MR. BOLGER: The answer to the question is no. Certain parameters that are correlated with each, for example, liquid temperature and air space temperature, were statistically varied along the same trajectory.

MEMBER POWERS: So you assumed 100 percent correlation of those.

MR. BOLGER: That is correct.

MEMBER POWERS: You assumed 100 percent --

MR. BOLGER: That's correct. That's correct.

MEMBER STETKAR: So you didn't independently sample those.

MR. BOLGER: Those parameters were assumed to be correlated. Other parameters were assumed to be independent.

MEMBER ABDEL-KHALIK: So what is the minimum assemble of parameters that is totally independent?

MEMBER BANERJEE: It's curiouser, and curiouser.

MEMBER STETKAR: Well, there aren't that many. Which ones were correlated in the sampling process?

MR. BOLGER: I'll see if I can say it properly. I'd say reactor power was independent, decay heat was independent, the pool temperature was --

MEMBER POWERS: How can decay heat and reactor power be independent? That can't be.

MR. BOLGER: Well, reactor power, decay heat as it relates to the starting value is, obviously, related, but when you look at the uncertainty of the distribution as it decays in time, it's not.

MEMBER STETKAR: Burnup.

MR. BOLGER: The suppression pool temperature can be, the air space, and the pressures in the pool were assumed to be 100 percent correlated, the service water was assumed to be independent. The heat exchanger was assumed to be independent. The leakage rate was assumed to be independent.

MEMBER POWERS: Go back to the previous slide, please, where it says not everything will be at the maximum or the minimum value, but some of them will.

MR. WOJCHOUSKI: That's for the deterministic approach. That is with --

MEMBER POWERS: When we come to the statistics, it says, "All input parameters will not be at their extreme values at the same time, but some of them will." Which ones are, and which ones are not?

MR. WOJCHOUSKI: That's a random sampling --

MEMBER POWERS: You told me that that was not the case. You told me that some were highly correlated.

CHAIRMAN SHACK: He's only sampling from the independent variables. The other variables --

MEMBER POWERS: But I can't figure out which ones are the independent --

CHAIRMAN SHACK: Well, yes, that's a little confusing.

MR. WOJCHOUSKI: We're taking random sampling off the independent variables and using that --

MEMBER POWERS: Which ones are the independent variables? These are not.

CHAIRMAN SHACK: I mean, your bullet here is misleading in the sense that they're statistically varied. It makes it sound as though they're all independent, and clearly some subset are not.

MEMBER APOSTOLAKIS: I think he means they considered variability in each one of these. Statistically varied, I think that's what it means. It's not a correct --

CHAIRMAN SHACK: Yes, but you have to know which of these are independent, and which ones are correlated.

MEMBER APOSTOLAKIS: I think that -- but, again, I think there is a slight confusion between correlation and dependence. I think the responses we're getting really refer to dependent value. If I know this value, I know this other one, because I can calculate --

cHAIRMAN SHACK: Right. It's 100 percent correlated.

MEMBER APOSTOLAKIS: You can call it that, yes. But Dana's question is something different. Right? You're saying if this variable tends to go to high values, this other variable tends to go to high values, too. So somehow you have to account for that.

MEMBER POWERS: Oh, if they come back with a sophisticated answer on correlation, I would have gone one more step and asked him whether they were doing Spearman correlation, or Pearson correlation.

MEMBER APOSTOLAKIS: Has there been a Subcommittee meeting on this topic?

MEMBER ARMIJO: No, this is just an informational --

MEMBER APOSTOLAKIS: I'm beginning to think more and more from this, we need one.

MEMBER POWERS: I mean, here we're looking -- we're asking a simple question here, and we're not getting a simple answer. The next question, of course, is having defined whatever the truly statistical value sample, what distribution do you use? And how do you keep that --

MEMBER APOSTOLAKIS: When in doubt, log

normal.

(Laughter.)

MEMBER ABDEL-KHALIK: But, you see, the trouble with that -- I think the message that you should take away from this is that this issue needs to be clarified in the topical report, and any follow-up presentation that will be made to the Committee as to an explanation of how the sampling is done.

MEMBER BANERJEE: Is this going to come up in front of a Subcommittee?

MR. DENNIG: It will review the topical. You'll be able to review the topical.

MEMBER ABDEL-KHALIK: I suspect that we will get an opportunity to review the topical report once it is formally submitted. And at that point, we can explore this much further, but they're looking for preliminary input at this stage, and the input you're getting is that this needs to be clarified.

MR. BOLGER: Clarify the correlations.

MEMBER BANERJEE: Well, certainly the sampling does. But, also, the answer that I've heard about SuperHex up to now is less than convincing in the sense that this was optimized to predict containment pressure for design-basis accidents, where you were trying to calculate the maximum pressure.

Here you're trying to predict the minimum, opposite problem, so I think that needs to be clarified, its capability to do that.

MEMBER ABDEL-KHALIK: Moving on.

MR. WOJCHOUSKI: Thank you. Statistical approach, the value of Hww is calculated as function of time for each of the multiple 59 trials based on the outputs of pool temperature, pool volume or the height, and the wetwell air space pressure. From the set of the 59 time histories, the minimum value of Hww is obtained as a function of time, and the resulting minimum values are used as the 95-95 value.

Going on to the effects of reduced NPSH on ECCS pumps. Effect of reduced NPSHa below the required will cause increased cavitation reduction in the total dynamic head of the pump. The effects will be flow surging, increased noise and vibration levels at the pump, and as the NPSH further reduces a condition called head collapse will be entered. This condition is where the percentage of liquid that is in the vapor phase is so greater that the pump flow ceases. Pump tests --

MEMBER POWERS: Do you get over-current trip in the motor before that occurs, in practice?

MR. WOJCHOUSKI: You could. Pump tests,

this is from the pump manufacturers, were performed for extended periods of time. What was given in the literature was two to three hours, where NPSH was substantially beneath NPSHr. What was meant by that was between three and up to head collapse, but not including head collapse. At that time, the vendor said that they did visual examination of the pumps afterwards, disassembly, and there is no visible damage shown. They also went ahead and had cases in which they took pumps into head collapse, in which they actually run them for long extended periods of time and seen head collapse, but ran them up until they lost flow completely. After doing that, they also saw no visible damage on the pumps, and that the pumps were shown to recover after NPSH was restored.

MEMBER BLEY: How long did they let them run in those conditions?

MR. WOJCHOUSKI: That I don't have the information on.

MEMBER BLEY: That's really the key. Almost any pump will run for a little while like that, but we've seen some -- I think the big spray pumps are kind of similar to these, aren't they? Fifteen, twenty-five minutes, burned. I mean, you're not going to use them again.

MR. WOJCHOUSKI: Yes, but I've seen some tests where they actually ran for a day.

MEMBER BLEY: With no --

MR. WOJCHOUSKI: Yes.

MEMBER SIEBER: Well, it depends on the pump.

MEMBER BLEY: It depends on the pump.

MR. WOJCHOUSKI: It really depends on the pump.

(Simultaneous speech.)

MEMBER SIEBER: Well, a multi-stage pump like a boiler feed pump is going to fail pretty quick because you're pumping a lot of energy into a very small volume, very small mass; whereas, these pumps --

MEMBER STETKAR: They're single stage.

MEMBER SIEBER: They're single stage.

MEMBER STETKAR: High clearance.

MEMBER BLEY: There's a fair amount of clearance.

MEMBER STETKAR: That's right. But still --

MEMBER SIEBER: You get some re-circulation.

MEMBER STETKAR: If they're going to fail, it depends on the time --

MEMBER SIEBER: Sooner or later they --

MEMBER STETKAR: Running them for five minutes like that doesn't really --

MEMBER BLEY: Will be all right.

MEMBER SIEBER: They could. I've seen -- I've actually seen test results where they ran them for 24 hours, a pump I'm aware of.

MEMBER STETKAR: I have too, when you take the pump apart, and the power is all pitted and everything. Nobody seemed to notice anything.

MR. WOJCHOUSKI: I'll just go ahead and answer your question about the time duration on this. If you're actually doing this, you have operators, it's in the control room. They have initiated these either in the suppression pool cooling or drywell sprays. They have guidance and EOPS that tell them to go ahead and watch for the flow. They're looking for surges. They go ahead and notice that the flow absolutely collapses, goes away. They'll go ahead and turn off the pump. It's not doing anything for them.

MEMBER BLEY: Sometimes they do, and sometimes they --

MEMBER SIEBER: Surges may develop some time after you start the pump, as everything heats up.

MR. WOJCHOUSKI: The other thing that we

have within EOPS, like was mentioned earlier by Rich, is there's curves which has the temperature of the suppression pool, the pressure of the drywell, and the flow rate of the pumps. So within the procedure there's a guide to the operators to watch those curves. As you get into cavitation, to go ahead and throttle the pumps down, or make sure that there's adequate NPSH. Monticello specific EOPS has a caution in it that says if you're less than 7 PSIG, that pump cavitation may be occurring.

Risk assessment. Risk assessment assess the impacts of the plant risk, containment accident pressure is assumed not present during the postulated accident scenarios, such that inadequate low pressure ECCS pumps NPSH occurs. The DBA-LOCA risk assessment presents a specifically generic and conservative such that the results are applicable to the BWR fleet. Non-LOCA events are also considered in the analysis in a simplified fashion to try to bound the BWR fleet.

The risk assessment impacts resulting from the example plant for containment over-pressure credit for the DBA LOCA are the delta and core damage frequency is 9 times 10 to the minus 9^{th} per year, and the delta large early release frequency was also conservatively assumed to be the same value.

MEMBER BLEY: Alan, I think we need to hear a real detailed explanation of the PRA scenario exactly what the operators are doing, what the equipment does, if the pumps are stopped, when they're restarted, how this can really be that these pumps have no -- that loss of suction on these pumps has no impact on the ability to survive that LOCA.

MR. WOJCHOUSKI: We have a presentation, and if we have time, we can go into it. It is a simplified very bounding-type of analysis that goes through and comes up with these --

MEMBER BLEY: At this level, it sounds like you don't need these pumps to work to survive. Is that true?

MR. WOJCHOUSKI: For the delta CDF this is supposed to be what is the change in core damage frequency if you go ahead and lose --

MEMBER BLEY: Compared to the pumps actually working. So they're somehow working under this condition, and you're giving credit for that, or the operators are doing something to make them work, or you don't need these pumps.

MR. WOJCHOUSKI: You have a low probability of all the events that lead up to this condition.

MEMBER BLEY: So it's likely you'll have net positive suction head is what you're telling -- okay. So the scenario that has not enough pressure to drive these pumps is very low in frequency.

MEMBER APOSTOLAKIS: What does DBA-LOCA mean?

MR. WOJCHOUSKI: Design-basis LOCA means that it's the recirc guillotine break, which is the largest break that Monticello has, and most BWRs have. Monticello, it's a 28-inch recirc suction line break.

MEMBER BLEY: But then unlike the DBA, things can fail.

MEMBER APOSTOLAKIS: Unlike?

MEMBER BLEY: In the DBA, you have one failure.

MEMBER APOSTOLAKIS: Yes.

MEMBER BLEY: Here, they're allowing more things to fail. They're just using the same initiating event. I think that's what you're saying.

MEMBER APOSTOLAKIS: Is that what it means? You can have multiple failures?

MR. WOJCHOUSKI: You have a DBA-LOCA, and then our net positive suction head calculation has one single additional failure that we analyze to for the small --

MEMBER APOSTOLAKIS: And that single failure is assumed.

MR. WOJCHOUSKI: Assumed.

MEMBER APOSTOLAKIS: It doesn't have a probability, it's assumed.

MR. WOJCHOUSKI: It is assumed, 100 percent.

MEMBER BLEY: But to get to CDF or LERF, you have to have multiple failures.

MEMBER APOSTOLAKIS: Yes, that's what confuses me.

MEMBER BLEY: You have to go beyond your design-basis --

MR. WOJCHOUSKI: Right, to finally get up there.

MEMBER APOSTOLAKIS: So if I assume a single failure, but for the LOCA itself, you put the frequency there.

MR. WOJCHOUSKI: There's a probability for having a LOCA.

MEMBER APOSTOLAKIS: This is a very selected use of PRA. I mean, you put the frequency of the initiator, but not the probability of the single failure. That's assumed to exist.

MR. ANDERSEN: No, George. Can I answer?

MEMBER APOSTOLAKIS: Yes.

MR. ANDERSEN: This is Vince Andersen from Aaron Engineering. Yes, this is the accident sequence itself. These are very isolated accident sequences, and so they are large LOCAs with the containment unisolated, with the likelihood of having these undesirable initial plant states, such as a high pool temperature, high ultimate heat sink temperature. Then assuming that that results in inadequate NPSH for the low pressure pumps, assuming with a probability of one that they go away, assuming -- then doing a human error probability that they don't throttle the pumps in the scenarios where that would help. So, yes, those issues are all in that answer.

MEMBER BLEY: So it's the design-basis now can account --

MR. ANDERSEN: Yes, direct --

MEMBER BLEY: -- things that you're asking for without the conservative assumptions. They're letting things happen as they would probabilistically, rather than saying we'll get the lowest possible pressure and the highest possible temperature.

MEMBER APOSTOLAKIS: But this is not a delta CDF, in the standard use of the word.

MR. ANDERSEN: Yes, it is.

MEMBER APOSTOLAKIS: Yes, it is?

MR. ANDERSEN: Yes, it is. Yes, if you --

MEMBER BLEY: So the original one is the one -- what is the original one?

MR. ANDERSEN: It's not a delta CDF if you say it already exists in the plant in the PRA model, but these negligible almost sequences don't exist in the model. And assuming that there's a DBA containment over-pressure issue that is really real in the PRA model, then it's -- we add it to it and there's the delta.

MEMBER APOSTOLAKIS: But you say this is the DBA, so you have assumed the existence of a single failure.

MR. ANDERSEN: I apply a frequency to it.

MEMBER POWERS: It assumes a large LOCA.

MEMBER BLEY: The big pipe break is all -- when they say a DBA-LOCA, they just mean it's not a pipe break. That's all. Right?

MEMBER APOSTOLAKIS: Then it goes to a PRA with multiple failures.

MR. ANDERSEN: Correct. Yes.

MEMBER BLEY: Any kind of failures.

MEMBER STETKAR: But only for that

initiating event.

MR. ANDERSEN: Correct.

MEMBER STETKAR: What would be the change, though, for the more likely contributors to real core damage, those being smaller LOCAs?

MR. ANDERSEN: That's -- so the -- this, I would say, is on the conservative -- even though people think PRA realistic, there's still conservative elements in the PRA for these sequences, so I can bound the fleet. One of them is, is that the large LOCA in the PRA is any break greater than a 6-inch diameter hole, and so, obviously, that's a much smaller LOCA than these DBA calcs.

MEMBER STETKAR: Transients and small LOCAs where the operators blow down to the suppression pool.

MR. ANDERSEN: That, if you want to drag that into the PRA, it's probably --

MEMBER STETKAR: Wait a minute. It is in the PRA.

MR. ANDERSEN: Yes, it is.

MEMBER STETKAR: It better be.

MR. ANDERSEN: If you want to drag the DBA aspect to containment over-pressure and that sort of thing into there, that, correct, is about an E to the minus -- 5e to the minus 8 sequence.

MEMBER BLEY: Net positive suction head is in the DBA. I mean it's a real issue.

MR. ANDERSEN: It is a real issue. Yes, it is a real issue.

MEMBER APOSTOLAKIS: I still don't know why you want -- first of all, aren't we going to have another chance to review these things? I think I was told --

MEMBER BLEY: We're going to get a report.

MEMBER APOSTOLAKIS: We're going to get a report, and maybe have a Subcommittee meeting.

VICE CHAIR BONACA: The topical will contain this level of detail, and the description.

MEMBER BLEY: Not just results?

MEMBER ABDEL-KHALIK: I think the purpose of this presentation, to a large extent, is to get feedback from the Committee as to where the questions are going to be, so that when we have the opportunity to review the topical report, and hear a full presentation, they will address these issues.

MEMBER APOSTOLAKIS: I'm still a bit confused as to what 1.174 is doing here. 1.174, suppose you having a licensing basis. You want to change something. You see whether the limits are met.

Here, we're not changing anything.

MEMBER SIEBER: Changing the calculation.

MEMBER APOSTOLAKIS: Trying to dismiss something.

MEMBER STETKAR: I mean, you could argue.

MEMBER APOSTOLAKIS: Well --

MEMBER STETKAR: But 1.174 is supposed to apply to total CDF, not delta CDF from one accident scenario.

MEMBER APOSTOLAKIS: That's very true. But, also, it's supposed to apply to proposed changes in the licensing basis. What is the proposed change in the licensing basis here?

MEMBER BLEY: Well, the previous -- the Reg Guide, as I understand it, says you have to have net positive suction head without taking credit for any over-pressure in the containment. The change is they're going to let them take credit for the pressure in the containment. The Reg Guide in the conservative way in these PRA calcs are trying to say in a realistic way.

MEMBER STETKAR: It changed the licensing basis. It's not a change to a plant.

(Simultaneous speech.)

MR. LOBEL: This is Richard Lobel of the

staff. Let me just clarify. I think you got it right. This topical report would be invoked by a licensee who came in with a license amendment request to somehow change their licensing basis in a way where they thought they needed credit for containment accident pressure for net positive suction head. It could be a power uprate, it could be a change to a heat exchanger, it could be all kinds of things, but it would be, most likely, from a licensee for a license amendment request, so it would be a change to the license.

MEMBER BLEY: And the Reg Guide will tell how to do this calculation conservatively. Will it deal with the kind of things we've been hearing about, the simulation calculations and things like that, or would that be left up to the licensee to --

MR. LOBEL: You mean SuperHex? Are we back to SuperHex? No.

MEMBER BLEY: Yes, the 95-95 --

MR. LOBEL: Oh, that, yes. The statistical part of it is really what this topical report is about.

MEMBER BLEY: Okay.

MR. LOBEL: SuperHex is not part of what this topical report is about. Okay.

MR. WOJCHOUSKI: Moving on, page by page. Example plant analysis. Monticello specific plant data was provided to General Electric for the NPSH analysis. Five years of plant data on 80 input parameters and probabilities distributions for each parameter was provided.

The analysis was done for DBA-LOCA and was completed with three different scenarios. One is a short term, which is less than 600 seconds. The 600 seconds is a 10-minute operator no action time. We used a single liming failure for NPSH considerations. For Monticello, that happens to be failure of LPCI loop select. Monticello has LPCI loop select logic. This will assume that it picks the wrong loop, and all your flow is going not to the vessel or core, it is going out of the break into you drywell.

We assume that all pumps are at run out, so we have four RHR pumps. They're putting over 17,000 gallons of water into our drywell, which is essentially spraying down the drywell, so that will minimize your containment pressure. That's why that was picked as a single limiting failure for the short term.

The long term analysis is greater than the 600 seconds. This is where you can credit operator action has already taken place. The limiting single failure for Monticello is a loss of diesel generator. Assume that you already have a loss of off-site power for the DBA-LOCA, we also come in and we remove one of our diesel generators. What Monticello is left with is one division of RHR, and one division of core spray which entails one core spray pump and two RHR pumps. At 600 seconds, they take one of the RHR pumps and turn it off, put on RHR service water so that you have cooling water to the heat exchanger. The other RHR pump is taken away from injecting in the vessel and put in suppression pool cooling, so you have core spray that's maintaining your vessel level, and you have suppression pool cooling going on at that time. The inputs are selected for NPSH to minimize over-pressure, and to maximize your containment, or suppression pool temperature.

MEMBER MAYNARD: Did you look at were there any scenarios where if the operators took action within the first 10 minutes, that it was worse for the NPSH, or do you have procedures that flat require your operators to not take any action for 10 minutes?

MR. WOJCHOUSKI: We -- operator action before 10 minutes in realistic time, they can go do it. This is an analytical version in which 10 minutes you can't credit for. For the pumps for NPSH, if operator action is done before the 10 minutes, the pumps are at run out. What they do is they would throttle those back, throttle them back; therefore, you would need less NPSHr, and have more NPSH available, so that would --

MEMBER MAYNARD: And I believe that for most of the things that I can think about. I'm just really asking did you take a review in the first 10 minutes, is there a scenario that if they did take certain actions within their procedures, that it created being less than --

MR. WOJCHOUSKI: Through our design-basis, when we first set all this stuff up, we looked for that sort of stuff to find the limiting stuff, did not find anything that if operator action happened before the 10 minutes, that would make it more severe than we've already assumed.

MEMBER MAYNARD: But at 10 minutes you did assume that they were guaranteed to switch over the RHR train, and RHR service water to suppression pool cooling.

MR. WOJCHOUSKI: Correct.

MEMBER MAYNARD: Okay.

MEMBER ABDEL-KHALIK: I think we're

running way behind, so please go ahead.

MR. WOJCHOUSKI: The last scenario was containment over-pressure failure. That scenario was done specifically for this topical report to address the concern what happens if you lose containment over-pressure, and you only -- that is your single only failure. In actuality, you'd need two active failures. In order to get there, you'd have to have two containment isolation valves fail, or you'd have to have the containment breach which is a passive breach.

We selected the porous air space breach in order to make sure that any of the energy released out of the reactor vessel is washed into the TOROS, and actually by doing that we're scrubbing that release, and you're maximizing the suppression pool temperature. If you had assumed that the breach of containment was in the drywell, all the energy is heading out the drywell, the suppression pool won't see the increased temperature, so it's conservative for the NPSH to assume where that break is, so it's a smart loss of containment.

All these three scenarios were done two ways, one was the deterministic approach, and the second one was the statistical Monte Carlo approach.

The first slide have some of the results. What this shows you is the top line, number 4, to be deterministic method. This is a comparison of the suppression pool temperatures for the short term DBA-LOCA, and we have LPCI loop select failure included in here.

What I would like you to take away from here is that you see that the deterministic is bounding over all the statistical. We provided three different lines. One happens to be the maximum, the mean, and the minimum results out of suppression pool temperature from the 59 different cases.

MEMBER ABDEL-KHALIK: Do you mean maximum, or do you mean -- okay, you mean the maximum. Right.

MR. WOJCHOUSKI: Maximum.

MEMBER CORRADINI: Not 95-95, but of the 59 calculations, that's the big one.

MR. WOJCHOUSKI: That's the big one.

MEMBER CORRADINI: Okay.

MR. WOJCHOUSKI: Then we come along, and if you also notice that seeing how this is only out to the first 10 minutes, that all these values are relatively close together, whether it's the deterministic or the minimum statistical. There's approximately 20 degrees difference between them.

Now we move over in suppression pool long term. You'll also see, again, that the deterministic, which is line 4, is bounding. It's high above everything else. Then you have the statistical maximum mean, and a minimum, again, on these. If you look in-between the statistical maximum and the deterministic maximum right at the one point, you have approximately 20 degrees just in-between those two, so it's spreading out.

This is the RHR pressure required for adequate NPSH short term. This is a busy curve, but it shows you a lot.

MEMBER CORRADINI: So I just wanted to understand, you don't have to go back. So you pick this up, the second slide you showed, you're picking up at the time when you switch to diesel generator failure, and so this just paces where you were to longer times with failure?

MR. WOJCHOUSKI: What you do is one scenario in the short term for the first 600 seconds.

MEMBER CORRADINI: Right.

MR. WOJCHOUSKI: And that's its own analysis. For the long term, you go ahead and have the same diesel failure for the first 600 seconds that is not bound for NPSH, so you don't use it.

MEMBER CORRADINI: Right.

MR. WOJCHOUSKI: And then you continue on with the same scenario with one diesel failure from 600 on, because that becomes the bounding --

MEMBER CORRADINI: Okay. Thank you.

MR. WOJCHOUSKI: So it's just --

MEMBER CORRADINI: Right.

MR. WOJCHOUSKI: The dotted line across here happens to be 14.26, which we use in Monticello for our atmospheric pressure. It's the lowest we've had weekly average, as well as monthly average. The next one happens to be, the square happens to be the deterministic pressure required for NPSHa to equal NPSHr. You notice at the very beginning when there's plenty of available space that this is actually a negative number. You're actually pulling a vacuum over here. But it shows that deterministically towards the end of the 10 minutes is that you'll need a little bit of over-pressure. Statistically, it shows that it's much lower, and barely need anything at the 10-minute mark.

The red line up here is a wetwell over-pressure deterministically. So from that one calculation deterministically, this is what SuperHex calculated as what the over-pressure is available to you. A point to bring out is, I showed this to you, some of the people from TVA, and they said where did your pressure go? It drops off like a rock. I told them LPCI loop select, I have 17,000 gallons washing, spraying down the TOROS, and that's the reason why -- or the drywell, that's the reason why the pressure is dropping.

MEMBER CORRADINI: Because of the pool height.

MR. WOJCHOUSKI: Spraying it straight down.

MEMBER CORRADINI: I want to compare apples to apples. So you want me to -- one which should compare the red line to the squares.

MR. WOJCHOUSKI: To the squares, that's correct.

MEMBER CORRADINI: Okay. Thank you.

MR. WOJCHOUSKI: Those are deterministic, they go together.

MEMBER CORRADINI: Thank you.

MR. WOJCHOUSKI: The triangle line goes with the three lines above it. One is the maximum, one is the minimum, and the last one happens to be the mean of the statistical analysis.

Another busy slide. This happens to be the long term.

MEMBER CORRADINI: So one thing I guess I'm curious about, let me just tell you what I see, and you tell me if it's wrong. So if I take the red with the squares, that delta is 2-1/2 psi 3. If I take the blue diamonds with the triangles, it's 3. It's not that much different.

MR. WOJCHOUSKI: This is the short term. There really isn't a lot of difference between them.

MEMBER CORRADINI: Okay.

MR. WOJCHOUSKI: When you see the real difference, happens to be the next slide, which was just put up, which is the long term. Here you'll go ahead and see that the squares happen to be deterministic wetwell pressure required. You're up at about 20 pounds, about 6 pounds of over-pressure that it says at your peak suppression pool temperature that you need. If you go ahead and look at that statistically, that comes down to approximately a pound and a half, in that range, so there's substantial reduction if you do it statistically more realistic methods.

The other thing is, yes, you take this red line which happens to be the wetwell pressure deterministic, that goes right along with you square box line. The other thing to go ahead and observe is that at this point on the triangles from statistically at its peak, it is actually where you need the wetwell pressure is where your suppression pool temperature is the highest. This is how your suppression pool temperature and the pressure, wetwell pressure tend to go in step. The higher temperature you have, the pressure also drives with it. The corresponding lines that you should be looking at isn't the minimum wetwell pressure statistically. It would be more in-between the maximum to the mean.

MEMBER ABDEL-KHALIK: Why is that?

MEMBER CORRADINI: Before you explain that, I was going to interpret these curves to mean the difference -- can you go back one, since the other one is easy, let's start there for interpretation. I'm sorry. Right, that one. So I'm supposed to compare the red to the squares.

MR. WOJCHOUSKI: That's correct.

MEMBER CORRADINI: And the blue diamonds to the triangles. Well, let's stick with the red with the squares.

MR. WOJCHOUSKI: Right.

MEMBER CORRADINI: That's the margin.

MR. WOJCHOUSKI: That's the margin.

MEMBER CORRADINI: Okay. And so what I said here, I still think is -- I thought maybe is close to right, which is the margin is not that much different whether I look at a deterministic method to estimate the margin, and a statistical method to estimate the margin. And then you came back with the next curve to say I shouldn't look at the minimum, I should look at something else. And I guess I don't understand that part.

PARTICIPANT: Short term versus long term.

MEMBER CORRADINI: Well, no, but it's still the --

(Simultaneous speech.)

MEMBER ABDEL-KHALIK: It's the same curves over a different --

MR. WOJCHOUSKI: This is different time period. So the triangle right here which your -- will be where your need the most amount of wetwell pressure to go ahead and have NPSHa equals NPSHr.

MEMBER CORRADINI: Right.

MR. WOJCHOUSKI: Equal those up. Is at a point in which you have the most suppression pool temperature, the highest temperature. As the suppression pool temperature goes up, trends up, it will drive the pressure along with it. So instead of comparing 59 runs to the minimum, the blue line is the minimum wetwell pressure, you would tend to line that up closer to the max, to the mean.

MEMBER CORRADINI: I had a feeling you guys were going to go there. So what you're telling me is, because I have a hot pool, I'll take credit for that in the over-pressure, the vapor pressure in the wetwell space.

MR. WOJCHOUSKI: If you're trying to line up exactly which case hit it.

MEMBER CORRADINI: Got it. Right. Now I see what you're saying. Thank you.

MR. WOJCHOUSKI: Does that make some sense?

MEMBER CORRADINI: It makes sense. I'm not sure if I would do it that way, but it makes sense, what you're saying.

CHAIRMAN SHACK: Why is the containment pressure for the deterministic calculation -- I thought it was going to be lower than the statistical one.

MR. WOJCHOUSKI: This runs into Hww, and I'll let Fran go ahead and kind of --

MR. BOLGER: This is Fran Bolger with GE.

It's actually expected that the -- statistically, you will drive a lower pressure. Considering that you're talking about lower temperatures in the pool, that will drive lower pressures in the containment.

CHAIRMAN SHACK: Okay.

MR. WOJCHOUSKI: This is the results of the long-term analysis. That shows deterministic and statistical, and the pressure of the wetwell deterministically, and statistically, so with the max.

MEMBER ARMIJO: From that curve could you tell me what the margin you have is? I'm back where Mike --

MR. BOLGER: This is Fran Bolger. Could you put up the curve with the Hww? It may not be on this presentation. It's still an open session slide, so I think if you've got it there.

MEMBER ARMIJO: I think you can answer my question by telling me which curve do I compare --

MEMBER CORRADINI: Do they propose we compare.

MEMBER ARMIJO: Yes. I'm catching up with Mike.

MR. WOJCHOUSKI: For?

MEMBER ARMIJO: That didn't help.

(Off mic comments.)

MEMBER ARMIJO: I think I know what to compare, but I'm not sure.

MR. WOJCHOUSKI: For the square, which is the deterministic you go up to the red line.

MEMBER ARMIJO: So the delta between that and any point along this time line is your margin.

MR. WOJCHOUSKI: Let's go ahead and just take the peak.

MEMBER ARMIJO: Okay.

MR. WOJCHOUSKI: Right here at that time frame will be the suppression pool peak temperature will occur there. It will also show you that this is where you need the most containment over-pressure to have NPSHa equal NPSHr.

MEMBER ARMIJO: Right.

MR. WOJCHOUSKI: What you've got is, this is what you need. Right here is what you have deterministically.

MEMBER CORRADINI: So can I inquire about that have? So in the red have, what temperature are you using to compute the partial pressure of water vapor in the wetwell? You're not using the suppression pool temperature; otherwise, you'd have a bigger have. What are you using to compute the total pressure there, because you have the highest - if I understood the way you went through the argument prior in the words, you're working your best to get the highest suppression pool temperature, which creates the biggest negative for H vapor pressure. And then you compute due to whatever the inventory is, and whatever the flows are, what the driving pressure is, which is the pool height, minus the loss. So what are you using for the wetwell temperature of the ambient for that red squares?

MR. WOJCHOUSKI: What we have right here, I'll just go ahead and take the one max.

MEMBER CORRADINI: Yes.

MR. WOJCHOUSKI: We get -- the GE code you get, at that point you get the peak suppression pool temperature, you have that. You go ahead and use that to calculate your vapor pressure at that one time step.

MEMBER CORRADINI: Yes.

MR. WOJCHOUSKI: Just that one time step. You also get what the calculation what the wetwell pressure is. The code goes ahead and gives that to you at that time step.

MEMBER CORRADINI: But when you compute that wetwell pressure, are you allowing the equilibrium between the pool and the ambient, or are you biasing the ambient to a temperature such that your pressure there is a bit lower? That was your -- what I thought I heard as an explanation, in the deterministic one, which is everything is logically connected. I'm just curious of what the temperature is of the wetwell ambient for the red.

MR. WOJCHOUSKI: For the red, I believe they're in thermal equilibrium, such that you have your TOROS water temperature, and your TOROS air space temperature is what you're asking.

MEMBER CORRADINI: Yes.

MR. BOLGER: This is Fran Bolger. What's the relationship between the pool temperature and air space in the wetwell?

MEMBER CORRADINI: Right. Because, I mean, all we're doing here is the laws of gases. Right? The red square is the air pressure at some temperature plus the vapor pressure at some temperature, minus the suppression pool temperature computed to a pressure. So I'm trying to figure out what your temperatures are in the calculation, so I can understand.

MR. BOLGER: Well, the temperatures are the temperature of the pool, and the pressures are as calculated by SuperHex. And those pressures are calculated with a mechanistic model between the pool surface and the air space.

MEMBER CORRADINI: In both statistical, and deterministic.

MR. BOLGER: Yes. This one is a difficult one to visualize margin, but if you calculate Hww as a function of time, then you could look at those terms in combination with each other, and look at relative margin in combination to see really how they compare to each other.

MEMBER CORRADINI: So let me ask you -- I'll stop at this point, and we can talk privately. But what's bothering me is, and maybe it's in there somewhere, is take the red square to the blue square, I get some delta.

MR. BOLGER: Yes.

MEMBER CORRADINI: If that's consistent, then I would expect that to map into one of your margin calculations statistically. And what I heard you say was, I ought to compare the blue triangle to the green, or somewhere between the green and the -whatever the hell the color is of the mean. And that gives me pause, unless I understand that I'm comparing apples to apples, which is air temperatures and water temperatures under the same conditions. Do you see why I'm --

MR. BOLGER: But to some extent this is -- you can't really see an apples to apples on the statistical in this chart. What you're seeing for the deterministic is, indeed, an apples to apples comparison.

MEMBER CORRADINI: Okay. Thank you. That's fair.

CHAIRMAN SHACK: We would see something different if we plotted one of the 59 runs and we looked at the pressures, and the temperatures. That's what's confusing our minds here, because we're grabbing samples from different runs and pasting them together here.

MEMBER ARMIJO: It seems like your margin is decreasing in the statistical approach.

MEMBER CORRADINI: Well, their argument --

MEMBER ARMIJO: And I would think it would go the other way.

MEMBER CORRADINI: But their argument there is we're naturally doing that. I still think I want to naturally do that to give myself good feelings. But they're saying the blue on the statistical is wrong, because that one tends to under-predict, or not under-predict, to use a air temperature which is lower and not coupled to the suppression pool temperature.

MEMBER ARMIJO: Okay.

MEMBER CORRADINI: As I heard your explanation.

MEMBER ARMIJO: Okay. Well, maybe this is the wrong time to try and do this.

MR. BLUNT: What we're trying to do on this one is that even with the statistical pressure, with that bottom triangular solid curve is that there's very little over-pressure that's needed. And then there's still margin even if you use -- engineering in feasible curve, like the blue curve, that is intuitively backwards, so that you should even -- even with that, there's still margin there.

MEMBER ARMIJO: Right. But it isn't 4 psi. It's 1 psi.

MR. BLUNT: Right. But it's not trying to measure apples and oranges. It's what it's doing.

MEMBER ARMIJO: It doesn't make physical sense, but there's margin.

MR. BLUNT: Correct.

MEMBER ABDEL-KHALIK: I think it would be very helpful if we plot the margin as a function of time for both the upper bound and lower bound and mean.

MR. BLUNT: There are other proprietary curves that will be in the LTR.

MR. BOLGER: We have another chart that you can see the margin, if you want to see that maybe in later --

MEMBER ABDEL-KHALIK: In closed session. Yes, I'd like to see it. Thank you.

MEMBER CORRADINI: Sorry to delay, but --

CHAIRMAN SHACK: It seems to me, one of the take aways here is that you still, in fact, need containment over-pressure.

MR. BLUNT: Correct.

CHAIRMAN SHACK: The statistics didn't get you all the way there. It bought you something, but you didn't get there, which I think you were hoping, presumably, to do.

MR. WOJCHOUSKI: It would be nice, but we won't guarantee it. On the next slide, happens to be the containment, loss of containment. What this shows is that your temperature for deterministically also is, again, bounding. You have your three temperatures for the mean, and the max, and the minimum.

What we also did was the over-pressure required. We showed that deterministically you would need containment over-pressure for this particular example, but statistically you would not.

MEMBER CORRADINI: So this is the one where it falls well with all systems available.

MR. WOJCHOUSKI: All systems available, statistically we underneath it. You don't need containment over-pressure. You actually have negative. So that's the one particular one in which we did, to answer your question, are they coupled? And this particular case, the only failure that you're assuming is loss of containment integrity, and you have all your ECCS available, and all your pumps. There's adequate cooling to make sure that you don't need it, so that's what the message is on this particular slide.

Special events. NPSH methodology for special events is presented in the topical report, a brief discussion of each of the special events are entailed. Similarities and contrasts between the DBA-LOCA and how we do the stuff, and identify conservatisms in each -- in the special event NPSH evaluation are described.

The NPSHa determinations will be completed on a plant-specific basis, expected that the determination approach utilizing nominal input values will be used to calculate the NPSHa for special events. That approach show that their NPSH available is less than NPSH required, but a statistical approach utilizing the mean output values will be used to show the expected realistic response to the event.

VICE CHAIR BONACA: When are you planning to submit the licensing report?

MR. WOJCHOUSKI: We have a topical that should be submitted next week.

VICE CHAIR BONACA: Okay.

MR. WOJCHOUSKI: We just had a BWR Owner's Group meeting with --

MR. BLUNT: Yes. We just approval of the version that we had that all these slides are presented and made upon. We will probably caucus and see if that is still acceptable to submit based on the feedback we got from today. Right now we do have a topical that was ready to be submitted next week. We'll make sure that your comments and the feedback from today is consistent with that. If it is, then we'll go ahead and submit it.

VICE CHAIR BONACA: Good.

MR. BLUNT: I don't want to commit to something based on not knowing.

CHAIRMAN SHACK: Now let me just get this straight in my head again. Now for a special event, because it's a special event, I'm allowed to do a sort of realistic calculation, which is why I do a nominal input value. And if I don't do that, then I do the statistical mean.

MEMBER CORRADINI: Nominal meaning systems available?

MR. WOJCHOUSKI: Nominal meaning instead of putting everything at the tech spec values, maximize, you can go ahead and take some of them and relax them, as long as they're still conservative.

MEMBER CORRADINI: But with -- just to help me with Bill's question, with all systems available?

MR. WOJCHOUSKI: You still have to go ahead and have a scenario development for each one of the special events. You have to define which equipment is available for you, and which is not, and it's based on the different special events.

MEMBER CORRADINI: Oh, okay. Okay.

CHAIRMAN SHACK: But he's got a set of stuff, and where he goes with nominal, versus --

MEMBER MAYNARD: It's more of a realistic expectation of what would occur, as opposed to --

MR. WOJCHOUSKI: And, typically, what

utilities will do is there's one or two values that they'll change to nominal, and still use the licensing basis on all the rest of them.

You wind up CDF and large early release frequency due to crediting containment over-pressure which is categorized as very small. And if the containment integrity is not available, ECCS can realistically perform its intended safety function.

MEMBER ABDEL-KHALIK: Thank you.

MEMBER MAYNARD: Just for my clarification. Currently, without this, each plant is having to do this on a plant-by-plant, plant-specific basis, if needed, with the NRC.

MR. WOJCHOUSKI: We've come up with a license amendment, submitted on it, show my calculations, asked for how much over-credit we need, and they review it and approve it.

MEMBER MAYNARD: And is the typical method used now for those who need and seek the containment over-pressure credit, is it primarily the deterministic method?

MR. WOJCHOUSKI: Exactly.

MEMBER MAYNARD: Okay. So this would allow the statistical approach, and it would be a generic; that would be any of the BWR plants coming in could use this as a basis for their plant-specific submittal.

MR. WOJCHOUSKI: Correct.

MR. BLUNT: But the submittal would still be based on deterministic. Statistical would be backup information to support the approval of deterministic.

MEMBER MAYNARD: Oh, okay. So they would still be doing a -- they would still be providing the deterministic analysis. Okay. All right.

CHAIRMAN SHACK: So we could have a case where you come in, and in the deterministic you ask for the net pressure credit, and your statistical analysis will show you don't need.

MR. BLUNT: Or need very little.

CHAIRMAN SHACK: It could show that -- potentially, yes. You need a lot less than you're asking.

MR. BLUNT: Correct.

MEMBER POWERS: I don't understand how this statistical analysis can be of any generic utility whatsoever, because the distributions are all peculiar to each plant environment.

MR. WOJCHOUSKI: The statistical analysis has to be done uniquely for each utility that's going in and asking for the credit.

MEMBER POWERS: Yes, you have to do the calculation for your plant.

MR. BLUNT: The methodology that says here are the input parameters that you need to get your data from your plant sites. Here's the way to run the 59 scenarios. Here's how to present it in plots and compare it to your deterministic would be the generic application of the methodology.

VICE CHAIR BONACA: It's just the most threshold margin for the plant-specific.

MR. WOJCHOUSKI: All we're trying to do on this is, the question is how much margin do you have, because if you it deterministically, you need all this containment over-pressure. What do you think you really need, the statistical method will try to answer that question. This is what we really think, and here's how much margin. This is what the difference between those two are. And it's just to give guidance on what the capability of the plant is.

MEMBER ABDEL-KHALIK: At this time, I'd like to just go around and see if members would like to provide specific input that would be helpful to you in either modifying your topical report, or preparing for the presentation to defend that topical report.

Jack?

MEMBER SIEBER: I don't have any comments for modification.

MEMBER ARMIJO: Yes, I don't know if the topical report will have proprietary information in it. Will it? It will, so there's stuff that we're going to see later that would be in the report?

MR. BLUNT: Yes.

MEMBER ARMIJO: I think this issue of correlation of input variables in the statistic analysis has to be made more clear. I don't really understand how it works, whether in a statistical analysis where you have two things that are dependent on one another, can they possibly be going in opposite directions? So I think you've got to sort that out, and I would somewhere along the line like to see what a good margin curve on temperatures, and pressures, and whatever it is for short-term and long-term.

MEMBER SIEBER: You're going to have a lot of margin curves.

MEMBER ARMIJO: Well, see, I don't -- I really don't understand the margins from the curves presented so far, except for the deterministic. I think I understand what you presented.

CHAIRMAN SHACK: As unrealistic as it is, it's understandable.

MEMBER ARMIJO: Yes, I understand unrealism.

MEMBER ABDEL-KHALIK: Sam, you're done?

MEMBER ARMIJO: That's it. Thank you.

MEMBER ABDEL-KHALIK: Dana?

MEMBER POWERS: The Monte Carlo analysis is completely inadequately described, that you have to address the issue of not only what the underlying distributions are, but what the correlations are. Then having said well, I've got a 95-95, you need to describe what the uncertainty bounds are on those values that you extract out of that. And I can only emphasize again that the underlying distributions have to be stoutly defined, and they have to begin by saying why do I think I have finite variance distributions on these things.

MR. WOJCHOUSKI: Could you repeat that last one, underlying distributions?

MEMBER POWERS: Why you think you have finite -- as George Apostolakis says, when in doubt, use a log normal distribution. Well, that's a distribution with a finite variance, why not use a Levy distribution? I mean, there has to be some defense for the distribution, and if you're going to base them on experimental data, then you've got to do something about showing that outliers don't exist, and that the data encompasses some realism to it. There's a lot to do on the statistical distribution.

Philosophically, I still think one has to approach these with great trepidation, because it is very much a part of the defense-in-depth that we're dealing with here. And as ardent structuralist, I grow nervous when PRA is used to attack defense-in-depth.

In any event, if you're going to use PRA, it has to be a fairly comprehensive PRA, it has to certainly include other things besides internal initiators.

MEMBER ABDEL-KHALIK: Mario?

VICE CHAIR BONACA: Well, I think that the concept here is a good concept to present to us what margin is available. That's really the fundamental issue, and the approach you're taking of still sticking with the -- your design-basis evaluation, and then presenting this as quantifying margin is the right thing to do. I agree totally with Dana that the statistical approach has to be supportable, and there are these open issues that we raised today, so I would expect you will go back and provide us with responses to those questions.

One last note I'd like to make regarding the presentation of data, some of the -- page 22 is somewhat confusing, and it took a while of discussion to compare apples and apples. And in some cases, we had apples and oranges are the same figure, so I would just pay some attention to that presentation of results.

MEMBER ABDEL-KHALIK: Okay.

CHAIRMAN SHACK: Again, I think the most critical issue is this correlation issue that Sam mentioned. I'm not sure you're going to be able to address all of Dana's issues, but you're certainly going to have to show the sensitivity to your choices of distributions at the very minimum.

The other one I think is this notion that I think you've addressed model uncertainty by using a conservative model, but I think you're going to have to make that argument a whole lot better than it was made today, if that is, in fact, the case.

VICE CHAIR BONACA: Can I add one thing I forgot?

CHAIRMAN SHACK: Yes.

VICE CHAIR BONACA: I also support the statement of Dana regarding cautiousness about credit.

We are down a path of accepting credit for back pressure, and some of the results we have seen in some of the presentations of specific applications were so marginal, and it seems to me that we cannot be cavalier about this issue. I mean, we want to know that your equipment will work under those conditions, and the risk doesn't mean that we're accepting failure. We are not accepting failure, in fact, doesn't mean the effectiveness of the systems.

MEMBER ABDEL-KHALIK: Thank you. Otto?

MEMBER MAYNARD: Well, overall approach and stuff, I believe that the current requirements of not allowing any credit for containment over-pressure is overly conservative, so I do think some credit should be given. The question is how much? I also agree with Dana and Mario that we need to be protective of that margin. I believe that there's margin in both ways, one typically we will pick NPSH required that is conservative, so there's a little bit of defense-in-depth with what's actually available. And then, also, I think we have to make sure that the analyses that are done are conservative, and that we still maintain a margin there. But I have no credit with the methodology that does provide some credit for that, I guess the real question is just how much.

The other thing I think in the methodology, and it may be addressed in the topical. We hit on it a couple of times here. It needs to insure that the applicants do take a look at operator actions, and make sure they look to make sure there isn't something that could be done in the first 10 minutes that you're not taking credit for in the operator action. That could actually make it worse instead of being conservative.

I don't think that will be all that difficult to do, but I do think it's something that needs to be done to make sure we're not just assuming that it's conservative to assume no operator action in the first 10 minutes.

MEMBER ABDEL-KHALIK: Mike?

MEMBER CORRADINI: Most of the stuff has been said. I'll just emphasize two or three things. One is the operator action issue that Otto brought up, I think John had to go somewhere for a minute, but I think this is the thing that he was dwelling on with Dennis. And I think the Owner's Group at least has to consider it, and address it.

In terms of, I guess my impression is -- I'm new to this. I'm listening to Mario about this, because with other uprates and other BWR cases, you've allowed this, so I think we're going from case-by-case to now a policy, and I think to have a policy here to require consistency is good. Therefore, I think we have to proceed with something in this regard.

I think Dana's -- I guess, I was listening to Sam and Dana, and I'd say between the two of them, the point that I guess I asked all the questions about is, I'm still trying to understand what you chose to be the variability going in, and how that variability is expressed in terms of what is the margin. And, so, Dana's point is on the robustness of what you're choosing going in. Mine was still trying to understand what you're comparing to given -- assuming for the moment that you chose a robust distribution, or a range of conditions. And I think that, at least for understanding how you want to approach it, still is my open question. So I guess I'm going to need to read when we get the details closely about that. Those are the three things.

MEMBER ABDEL-KHALIK: Let's go back. Sanjoy?

MEMBER BANERJEE: You know, I missed some of the discussion, but what I want to ask you is, are you asking these comments so that you take a final position, or are we --

MEMBER ABDEL-KHALIK: No.

MEMBER BANERJEE: -- going to be meeting again, and going through some more detail.

MEMBER ABDEL-KHALIK: We're not even writing a letter on this.

MEMBER BANERJEE: Okay. So let me give you what I feel right now, without having thought what -- it's that in some ways it's similar to what we try to do with LOCA in the sense that we were doing a best estimate plus uncertainty, and we developed a methodology to do this over a long period of time, which we call the CSAU methodology.

Now that is a very stylized way of doing things to understand what is important phenomena, to look at the uncertainties associated with that, to fix the way you're going to nodalize the problem, and there's a very systematic way of tackling these things.

I don't see this being done here. What I see is a bunch of inputs being varied, and some results being presented on this. This is, basically, a long-term cooling problem. If we don't have this, the core is going to be in deep trouble, so I think we need to address it like we address things like LOCA. I wouldn't do it lightly, so I don't see that sort of methodology here, where we look at model uncertainties. We understand all sorts of things very clearly. And I'm a little concerned about that.

VICE CHAIR BONACA: I think this is -- I agree with you, that you could go further than what is done and develop the model that is more realistic. And then we get probably more margin out of it. I think what they did, they limited themselves to looking at the margin you get by treating statistical inputs, inputs in a statistical way, rather than putting every parameter at the end point of the range, presumably conservative, over-conservative. So I still believe that you can gather some margin this way. Clearly, it's not all the margin you could get, but --

MEMBER BANERJEE: Well, if that's the case, I'm happy. But it has to be done.

VICE CHAIR BONACA: And the report, of course, has to point that. I believe that's what they've done.

MEMBER ABDEL-KHALIK: I think there is one issue that hasn't come up, which is -- okay. Well now you're back. I was -- we're just collecting comments and feedback. And I was wondering if you have any feedback to the presenters on issues that they need to take care of in the topical report before they actually submit it.

MEMBER BLEY: I think the main thing from my point of view is either in the topical report, or some attachment to it, letting us see the details of how the results of recurring analysis have been factored into the PRA, What the real physical scenarios are through the PRA, and how they were handled is real important for us to look at. So real details on it, not just results.

MEMBER STETKAR: I don't have anything to add.

MEMBER ABDEL-KHALIK: George.

MEMBER APOSTOLAKIS: I go along with my colleague.

MEMBER ABDEL-KHALIK: Okay. Well, thank you very much. Hopefully, you got enough feedback that would be helpful to you in modifying your topical report, and in preparing for actually presenting it.

MR. BLUNT: We do appreciate the opportunity, and I guess one thing we would like to emphasize I think that I've heard a little confusion about is, this topical report is not a submittal of SuperHex code. It's a submittal of a methodology to try to give margin to an existing code that's already pre-approved, or not pre-approved, but in existence and used throughout the industry. So we did not in this topical report go back and try to explain, or justify some of the items that were in the initial SuperHex items here. That wasn't the intent of the LTR.

MR. DENNIG: And the staff understood that as a boundary condition for the work.

MEMBER CORRADINI: The only thing I guess I want to emphasize is Sanjoy's point, I think is important for the industry to think through, which is that as much as ECCS stylized Appendix H things were relatively porous early, and then went to other approaches, the industry might want to consider the same sort of thing, because you're talking on long-term core cooling; therefore, all these sort of issues come back in a different form.

MEMBER BANERJEE: There are no artificial boundaries to be pushing. This is a serious business, so I think we can open it to whatever length detail of examination we need to satisfy ourselves.

MR. BLUNT: You can. You're more than happy, I'll just tell you that -- the topical report didn't include and wasn't based on trying to go back and justify SuperHex.

MEMBER BANERJEE: We weren't looking for justification --

MEMBER ABDEL-KHALIK: Model uncertainty has come up, and you need to address that. Well, thank you very much. Mr. Chairman, I return it to you.

CHAIRMAN SHACK: Thank you again. It's been a very interesting morning. We're ready for a break, I think. I'd say 11:05.

(Whereupon, the proceedings went off the record at 10:49:03 a.m.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Reactor Safeguards

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Eric Hendrixson
Official Reporter
Neal R. Gross & Co., Inc.

CREDIT FOR CONTAINMENT ACCIDENT PRESSURE IN DETERMINING AVAILBLE NPSH

Richard Lobel
Office of Nuclear Reactor Regulation
February 8, 2008

CREDIT FOR CONTAINMENT ACCIDENT PRESSURE

- PURPOSE

- Brief review of history and applicable NRC regulations and guidance related to the use of containment accident pressure in determining the available NPSH of ECCS and containment heat removal pumps

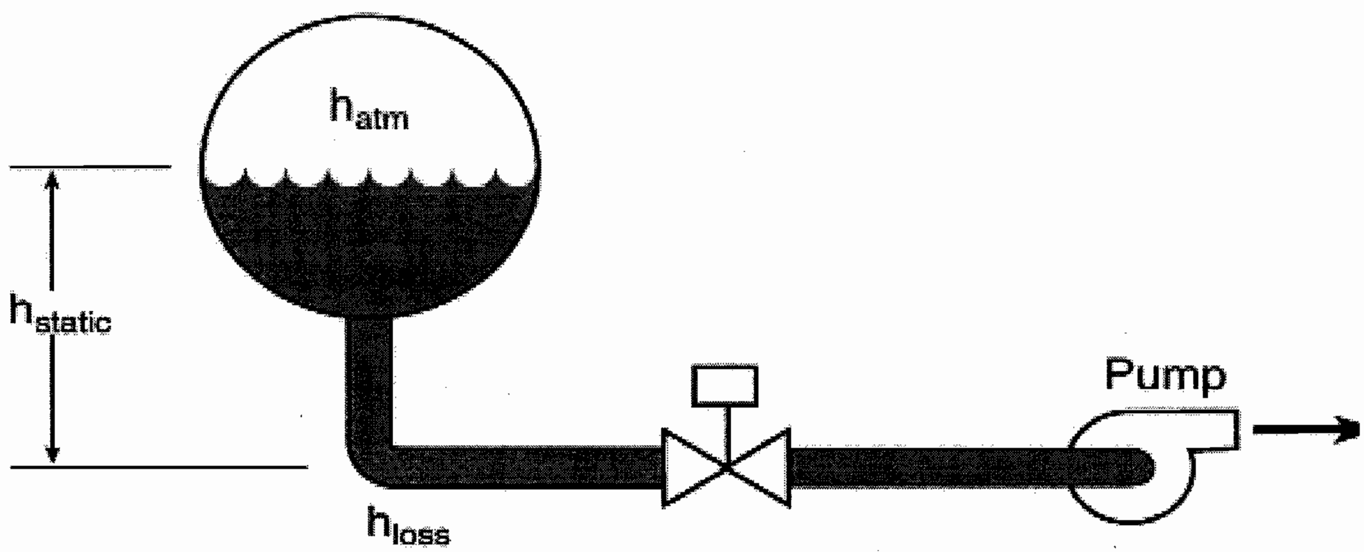
CREDIT FOR CONTAINMENT ACCIDENT PRESSURE

- Introduction

- Draft RG 1.82 Revision 4: An acceptable approach would quantify the uncertainty in NPSH calculations
- Discussions with BWROG
- NRC staff briefed on proposed BWROG method at October 2007 meeting.

CREDIT FOR CONTAINMENT ACCIDENT PRESSURE

$$\text{Available NPSH} = h_{atm} + h_{static} - h_{loss} - h_{vp}$$



CREDIT FOR CONTAINMENT ACCIDENT PRESSURE

- <u>BACKGROUND-1</u>

- Some early reactors licensed crediting containment accident pressure for NPSH
- Regulatory Guide 1.1: (1970)No credit for increase in containment accident pressure
- Regulatory Guide (RG)1.82 Revision 0: (1974) 50% blockage
- USI A-43: RG 1.82 Rev. 1: (1985) LOCA – debris blockage, air entrainment, sump design

CREDIT FOR CONTAINMENT ACCIDENT PRESSURE

- BACKGROUND-2

- Bulletin 96-03: RG 1.82 Rev. 2 (1996) BWR strainer guidance
- Generic Letter (GL) 97-04 (1997) Requested information on crediting containment accident pressure. Resulted in revisions to NPSH analyses for some plants.
- Bulletin 2001-03 (GSI 191): RG 1.82 Rev. 3 (2003)
  - No credit for containment accident pressure
  - Acceptable for certain operating reactors when design "cannot be practicably altered"

CREDIT FOR CONTAINMENT ACCIDENT PRESSURE

- Staff Position:
  - Credit for containment accident pressure in determining available NPSH is allowed when:
  - (1) analysis has conservatively demonstrated that sufficient pressure is available for design basis accidents, and
  - (2) for beyond design basis accidents, an acceptable level of safety is maintained

CREDIT FOR CONTAINMENT ACCIDENT PRESSURE

- <u>STATUS</u>

- Plants crediting containment accident pressure:
  - 18 BWRs (Mark I containments)
  - 10 PWRs (5 Subatmospheric containments)*

- Standard Review Plan Section 6.2.2 allows credit for containment accident pressure during the LOCA injection phase

CREDIT FOR CONTAINMENT ACCIDENT PRESSURE

- CREDIT IN OTHER REGULATIONS
  - 10 CFR 50.46 Containment pressure must be conservatively minimized
  - Dose calculations assume leakage at La (< 1percent mass/24 hours)
  - ATWS, Station Blackout and Appendix R (Fire) acceptance criteria require demonstration of containment integrity by satisfying containment pressure and temperature design limits

CREDIT FOR CONTAINMENT ACCIDENT PRESSURE

- ACCEPTABILITY OF CREDIT FOR CONTAINMENT ACCIDENT PRESSURE BASED ON:
  - High confidence in containment integrity
  - Conservative calculations
  - Design of emergency pumps
  - No significant impact on emergency operating procedures
  - Minimal impact on plant risk

Containment Overpressure Credit for NPSH

ACRS/NRC/BWROG Meeting

NRC Headquarters

Rockville, MD

February 8, 2008

Alan Wojchouski (NMC)
BWROG COP Committee Chairman

Purpose of Presentation

- Present background, objectives and work scope
- Provide overview of the Licensing Topical Report
- Describe how the LTR address ACRS concerns with granting containment overpressure credit

Background

- In late 2005, NRC requested BWROG to provide information that could be used by staff to address ACRS issues with approval of containment overpressure credit for NPSH

- Committee was approved by BWROG Executives in May 2006

Background

- BWROG Objective
  - Develop guidance for NRC approval of credit for containment overpressure where practical alternative approaches do not exist
    - Define conservatisms in methodology
    - Assess safety implications
    - Define reasonable and consistent requirements and methods

Results

- For DBA LOCA and Special Events, both the change in CDF and the change in LERF fall within the RG 1.174 “very small” risk increase region
- Deterministic (current licensing basis) approach gives a conservative assessment of NPSHa
- Statistical (realistic) approach demonstrates margin inherent in deterministic approach
- Low pressure ECCS performance not dependent on containment integrity
- Pumps have been shown to survive periods of operation when the NPSHa was below NPSHr

Work Scope

- Identify example plant – Monticello
- Review containment analysis inputs and methods for conservatisms
- Perform sensitivity study to assess impact of input parameters on containment response
- Identify input parameters in the example plant NPSH analysis that can be changed to minimize containment overpressure credit (COP)

Work Scope - Continued

- Perform containment analyses for example plant
  - Develop methodology
    - Licensing basis inputs – deterministic
    - Realistic inputs – statistical
    - Compare results
- Perform risk assessment using results of realistic analysis
- Assess effect of credit for containment overpressure on special events (i.e., Appendix R, SBO, ATWS)

Overview of Methodology

- Calculate NPSHa without COP (deterministically)
  - Conservative assumptions, for DBA LOCA and special events
  - Determine wetwell pressure so NPSHa = NPSHr

- If NPSHa without COP is lower than NPSHr,
  - Ensure deterministic NPSHa with COP is higher than NPSHr
  - Evaluate statistically (Monte Carlo)
    - This provides realistic evaluation of the event in support of COP request based on the deterministic calculations

NPSH Overview

- Available NPSH can be expressed as

$$NPSHa = [(Pww - Pv) \times 144/\rho_w] + [Hpool - Hpump - Hloss]$$
$$= \quad Hww \quad + \quad Hpl$$

Where:

NPSHa	Available NPSH for pump (ft)
Pww	Wetwell airspace pressure (psia)
Pv	Saturation vapor pressure at suppression pool temperature (psia)
ρ_w	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

- Current licensing basis accident scenarios with applicable limiting single failures are used in the NPSHa determination
  - Bounding values for containment initial conditions
  - Resulting pool temperature response is maximized and the available wetwell pressure 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 to achieve 95/95. 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

DBA LOCA Approaches

- Deterministic approach: Uses either the maximum or the minimum value for each input parameter
  - Depends upon which direction is conservative

- Statistical approach: All the input parameters will not be at their extreme (maximum or minimum) values at the same time
  - For the statistical approach with realistic assumptions, input parameters that can be statistically defined are selected

Statistical Approach

- The following input parameters were statistically varied:
  - Initial reactor power
  - Decay heat value after reactor SCRAM
  - Initial suppression pool temperature
  - Service water (ultimate heat sink) temperature
  - RHR heat exchanger heat removal capability
  - Initial suppression pool volume
  - Initial drywell temperature
  - Initial drywell pressure
  - Initial wetwell pressure
  - Initial containment leakage rate

Statistical Approach

- Value of Hww is calculated as a function of time for each of the multiple 59 trials (calculations), based on outputs of
  - Pool temperature
  - Pool volume (height)
  - Wetwell airspace pressure

- From the set of 59 time-histories, the minimum values of Hww are obtained as a function of time, and the resulting minimum values are used as 95/95 values

Effects of Reduced NPSH

- The effects of reduced NPSHa below the NPSHr will cause increased cavitation and reduction in the total dynamic head of the pump.
  - The effects will be flow surging, increased noise and vibration levels at the pump.
  - As the NPSHa is further reduced, a condition called head collapse will be entered
    - This condition is where the percentage of liquid that is in vapor phase is so great that pump flow ceases

- Pump tests were performed for extended periods where the NPSHa was substantially below NPSHr
  - Pumps were shown to recover after NPSHa was restored
  - No visible damage was noted after running for extended periods and after head collapse

Risk Assessment

- The risk analysis assesses the impact on plant risk if containment accident pressure is assumed not present (e.g., postulated pre-existing primary containment failure) during the postulated accident scenarios such that inadequate LP ECCS pumps NPSH occurs

- The DBA-LOCA risk analyses presented are sufficiently generic and conservative such that the results are applicable to the BWR fleet. Non-LOCA events are also considered in this analysis in a simplified fashion to bound the BWR fleet.

Risk Assessment Conclusions

- The risk impact results for the example BWR plant for COP credit for DBA-LOCAs are
  - Δ CDF = 9.0E-9 /year
  - Δ LERF = 9.0E-9 /year

- Both the change in CDF and the change in LERF fall within the RG 1.174 "very small" risk increase region

- Even with inclusion of Special Events and External Events, the risk impact is still "very small"

Example Plant Analysis

- Monticello plant-specific data was provided to GE for NPSH analysis
  - Five years of plant data for eight input parameters and probability distribution for each parameter

- 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 overpressure failure
  - Each in two ways
    - Deterministic approach (standard licensing basis analysis)
    - Statistical approach (Monte Carlo analysis)

Figure A-1 Comparison of Suppression Pool Temperature for Short-term DBA-LOCA (with Loop Selection Logic Failure) between Deterministic Analysis and Statistical Analysis

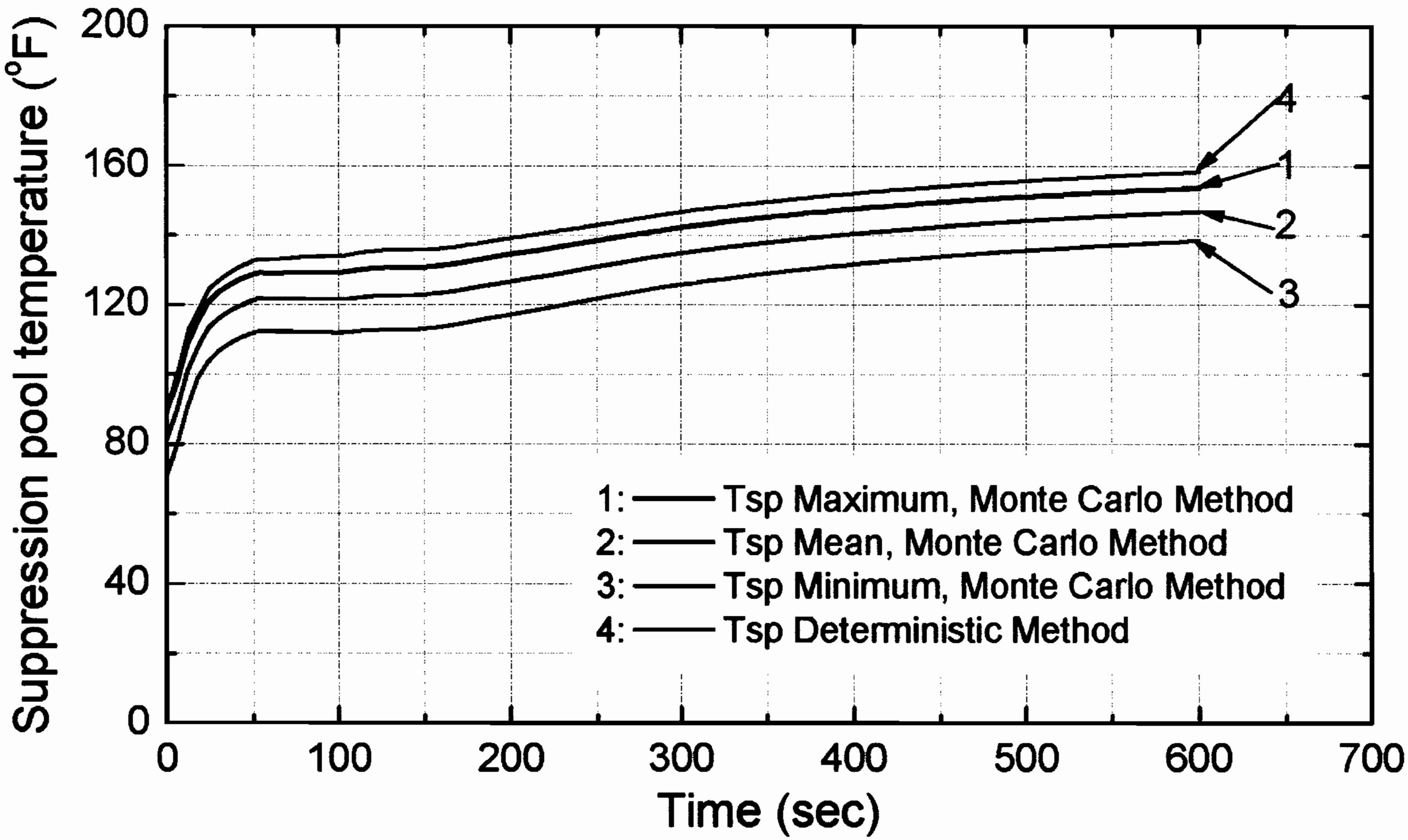
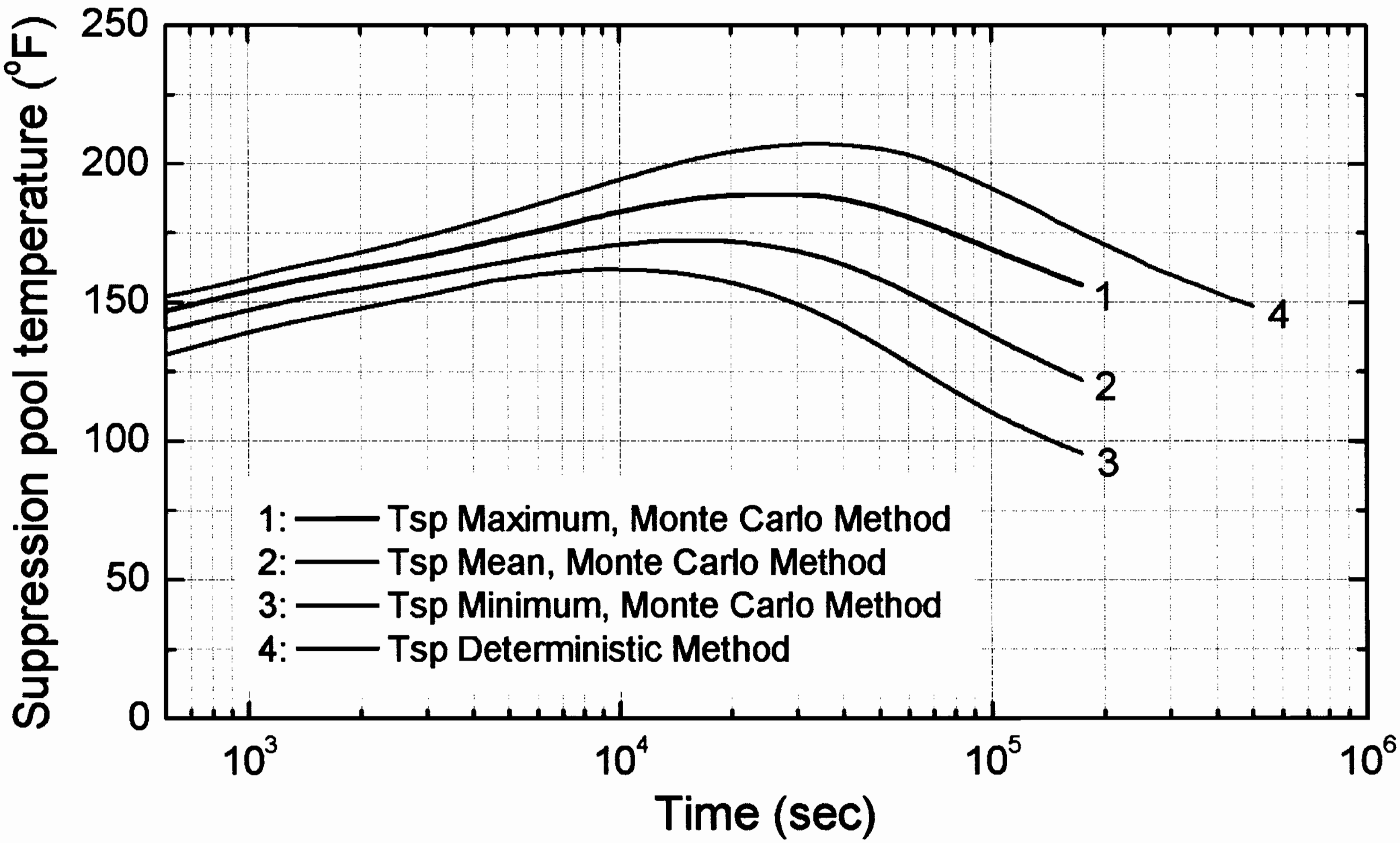
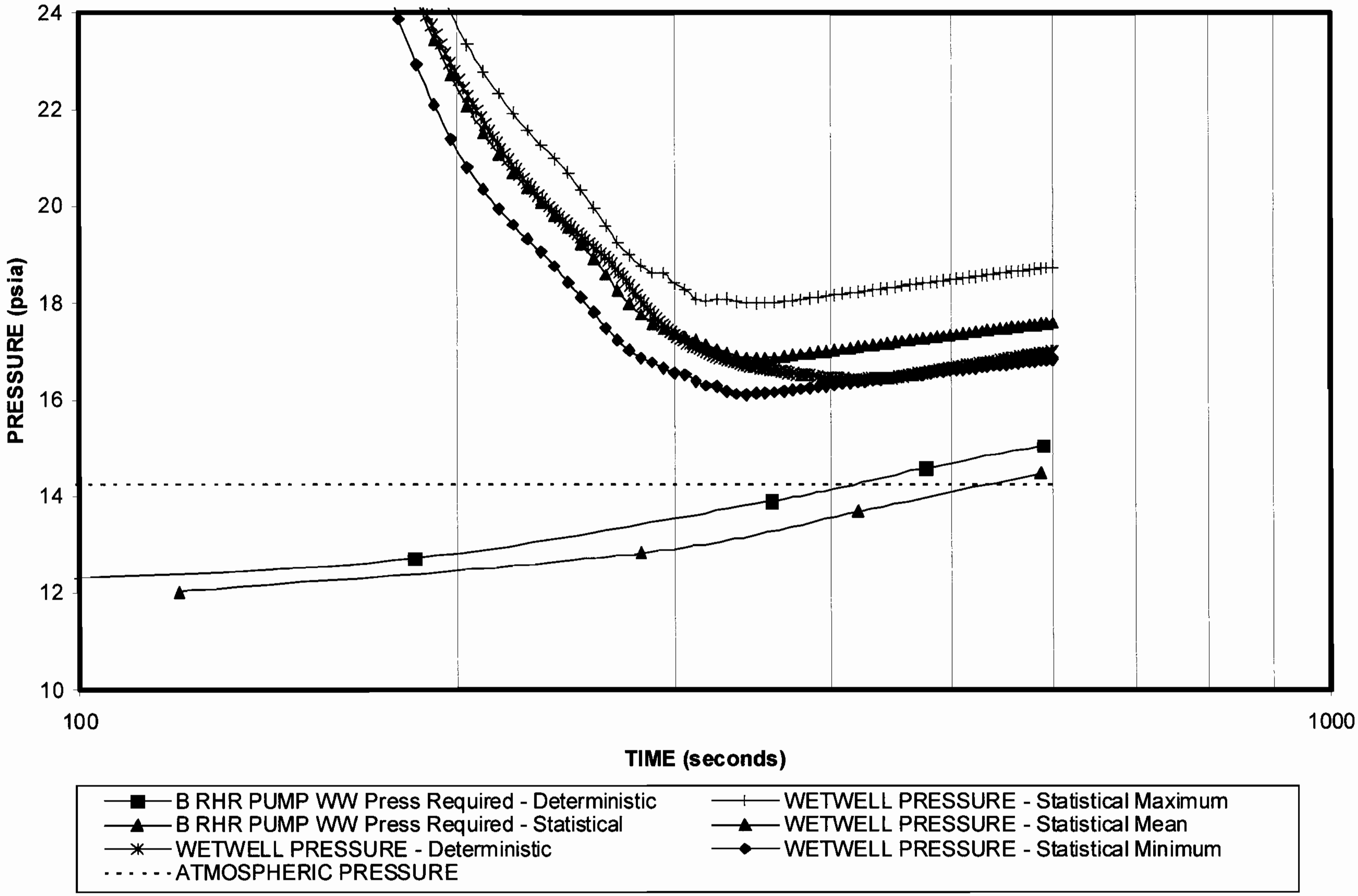


Figure A-2 Comparison of Suppression Pool Temperature for Long-term DBA-LOCA (with Diesel Generator Failure) between Deterministic Analysis and Statistical Analysis



RHR CONTAINMENT PRESSURE REQUIRED FOR ADEQUATE NPSH DURING THE SHORT TERM PHASE OF DBA LOCA (LPCI LOOP SELECTION FAILURE, OFFSITE POWER AVAILABLE AND DEBRIS LOADING ON SUCTION STRAINERS)



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)

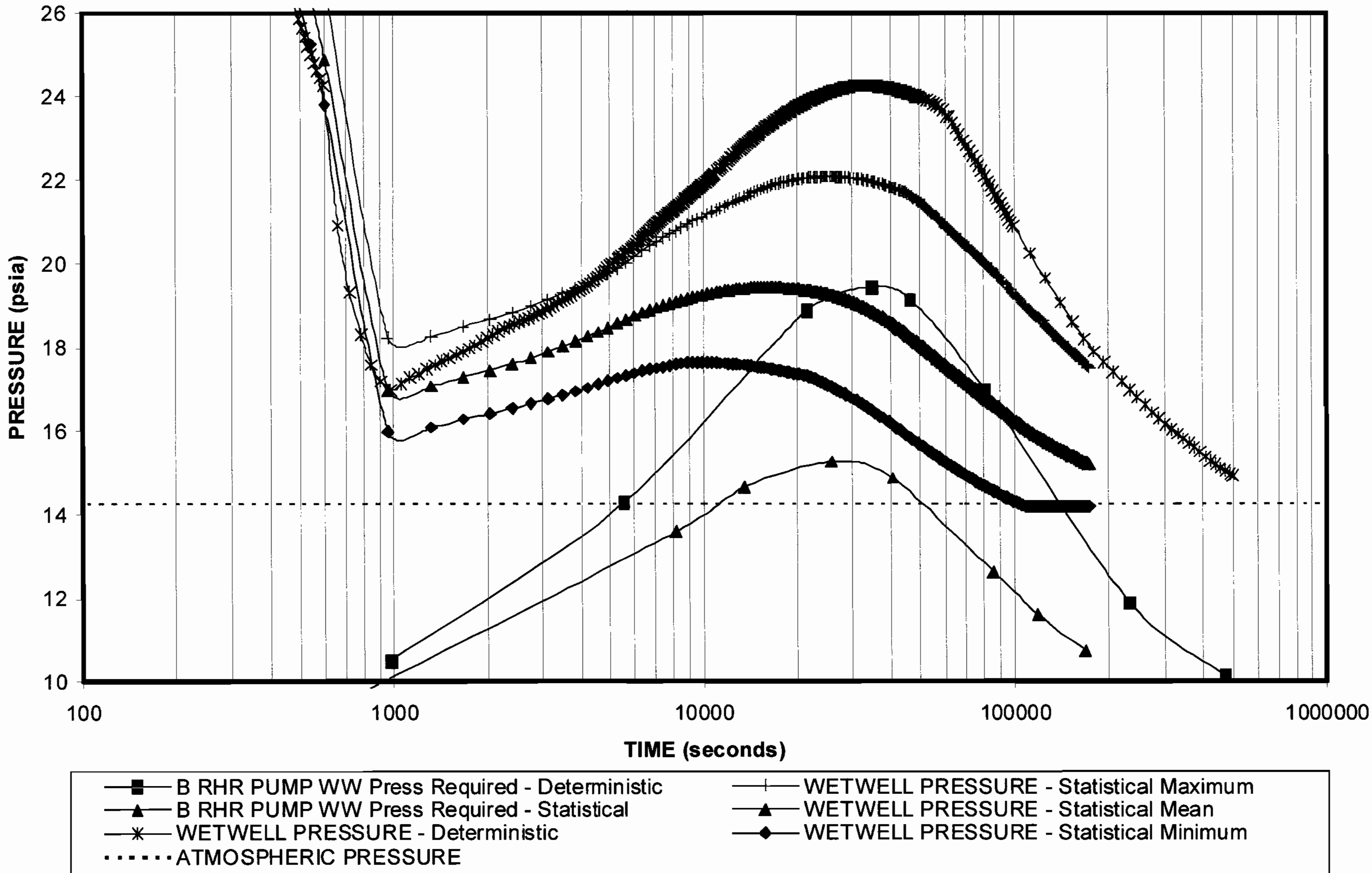
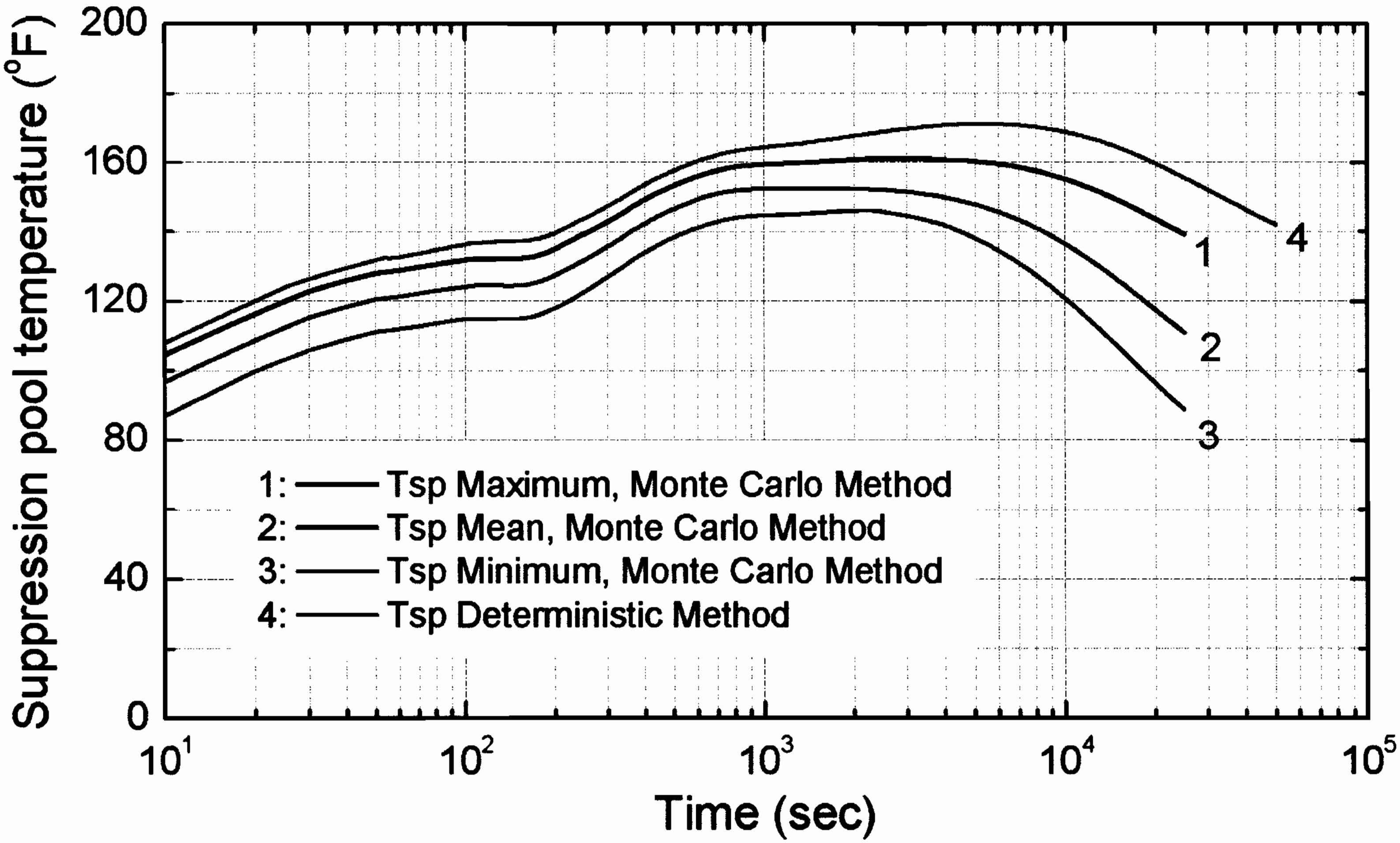


Figure B-1 Suppression Pool Temperature Response to DBA-LOCA with All Safety Systems Available for Case of No Containment Overpressure



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 NPSHa determinations will be completed on a plant-specific basis
  - Expected that the deterministic approach utilizing nominal input values will be used to calculate NPSHa for special events
  - Should this approach show that NPSHa < NPSHr, then the statistical approach utilizing the mean output values will be used to show the expected realistic response to the event

Conclusions

- The change to CDF and LERF due to crediting COP is "very small"

- If containment integrity is not available, the ECCS can realistically perform its intended safety function

Thank you for your attention