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UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

July 19, 2005

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

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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SUBCOMMITTEE ON THERMAL HYDRAULICS

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MEETING

+ + + + +

TUESDAY,

JULY 19, 2005

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The meeting came to order at 8:30 a.m. in room O-1G16 of White Flint One, Rockville, Maryland, VICTOR H. RANSOM, Vice Chairman of the subcommittee, presiding.

COMMITTEE MEMBERS:

GRAHAM B. WALLIS Chairman

VICTOR H. RANSOM Vice Chairman

RICHARD S. DENNING Member

THOMAS S. KRESS Member

WILLIAM J. SHACK Member

JOHN D. SIEBER Member

RALPH CARUSO Designated Federal Official ALSO

I-N-D-E-X

P-R-O-C-E-E-D-I-N-G-S (8:39 a.m.)

INTRODUCTION

VICE CHAIRMAN RANSOM: The meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Thermal Hydraulic Phenomena. I am Victor Ransom, Vice Chairman of the Subcommittee. I may look like Graham Wallis, but I am substituting for him. Subcommittee members in attendance are Graham Wallis, Tom Kress, Jack Sieber, Bill Shack, and Rich Denning.

I was asked announce that no food nor drink will be allowed in the Committee meeting room.

The purpose of the meeting today is to discuss the staff's proposed revision to Regulatory Guide 1.82, "Water Sources for Long-Term Recirulation Cooling Following a Loss of Coolant Accident, LOCA."

Tomorrow the staff will present the results of its ongoing staff research program associated with chemical interactions of coolant and debris within a containment during a loss-of-coolant accident.

The Subcommittee will hear presentations by and hold discussions with representatives of the NRC staff and other interested persons regarding these matters. The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate for deliberation by the full Committee.

Ralph Caruso is the designated federal official for this meeting. The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on July 8th, 2005.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register notice. It is requested that speakers first identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

This meeting is also being made available on a telephone bridge connection, and a number of stakeholders are listening in. I would ask all of the participants to speak clearly and distinctly so that the people on the telephone can hear you.

We have received requests from two members of the public to make presentations today. Mr. Bill Sherman from the Vermont Department of Public Service will make a presentation with the assistance of Mr. David Lochbaum from the Union of Concerned Scientists. Mr. Raymond Shadis from the New England Coalition will make a brief statement.

I would remind all presenters that the topic of today's meeting is the proposed staff regulatory guide and not any particular licensing activity that is associated with a particular plant.

In looking this over, I won't attempt any history. Hopefully Mr. Lobel will go over the history of this. But this Reg Guide 1.82 first was issued in 1974 and several revisions intervening.

We'll now proceed with the meeting. And I call upon Mr. Lobel of the NRC staff to begin.

2. OVERVIEW OF REVISED REGULATORY GUIDE

MR. LOBEL: Good morning. My name is Richard Lobel. I am a senior reactor systems engineer in the Office of Nuclear Reactor Regulation. Seated to me is Mr. Marty Stutzke, who is a senior reliability and risk analyst, also in NRR.

Next slide, please. We're here today to discuss a proposed revision to Reg Guide 1.82, Revision 3, as well as several other related documents. The purpose of the revision is to make the regulatory guidance on NPSH consistent between these documents and to revise the regulatory position on credit and containment accident pressure in determining NPSH margin.

As part of this effort, the staff has

reassessed our position on the use of containment accident pressure in determining NPSH margin. And a large portion of our talk is devoted to this reassessment.

The purpose of the presentation is to request ACRS approval to issue this proposed revision to Reg Guide 1.82, revision 3 for public comment.

Next slide, please.

CHAIRMAN WALLIS: The ACRS does not meet until September.

MR. LOBEL: Right.

CHAIRMAN WALLIS: Are you expecting a letter in September? Is that what you were looking for?

MR. LOBEL: Yes. And we would be prepared to come back and address the full Committee if you'd like.

CHAIRMAN WALLIS: So part of our job is to tell you if we think you are ready?

MR. LOBEL: I guess, yes.

CHAIRMAN WALLIS: All right.

MR. LOBEL: The documents being revised are the Reg Guide itself, Reg Guide 1.82, revision 3, which is "Water Sources for Long-Term Recirculation Cooling Following a Loss of Coolant Accident." Reg

Guide 1.1, "Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal System Pumps," Standard Review Plan section 6.2.2, "Containment Heat Removal Systems," and the review standard for extended power uprate.

The lats document hasn't been revised yet. The staff intends to revise the EPU guidance later this year. and the NPSH revisions will be made at that time. Actually, the staff's intent is to revise Reg Guide 1.82, revision 3, and reference the revision in the other documents.

Some of these documents deal with broader issues than NPSH, but we're here today only to discuss NPSH. No substantive changes have been made to these documents in any other area.

Next slide, please. The NPSH guidance applies mainly to ECCS and containment heat removal pumps during a LOCA. When PWR pumps are taking suction from the emergency sump and BWR pumps are taking suction from the suppression pool, the main focus is on the design basis LOCA, but as part of the reassessment, we examined all pertinent events.

Next slide. We divided the presentation into several subjects. In order to understand the current status, it's probably helpful to understand some of the history. So we'll begin with a regulatory background.

Next I'd like to present the proposed changes to Reg Guide 1.82. And then we'll provide the technical justification for crediting containment accident pressure and determining available NPSH.

Next slide.

MEMBER DENNING: Incidentally, I don't think we're getting the slides.

MR. CARUSO: I know because we don't have electronic copies that we can use on the track yet. We're getting that many. So right now we just have --

MEMBER DENNING: So you are just telling us to change.

MR. LOBEL: Right, yes.

CHAIRMAN WALLIS: You say here "Accident pressure"?

MR. LOBEL: Yes.

CHAIRMAN WALLIS: Isn't there something about maximum temperature, minimum pressure?

MR. LOBEL: Yes. I'll get to that.

CHAIRMAN WALLIS: That seems almost sort of inconsistent because usually high temperature means high pressure, doesn't it? I'm just wondering how you achieve this mysterious nonphysical situation of having a minimum pressure and a maximum temperature.

MR. LOBEL: Well, you do the containment analysis with assumptions that kind of lead you in that situation. I'll go through some of the assumptions.

CHAIRMAN WALLIS: We're going to get to that. Okay.

MEMBER KRESS: They're not real conditions. They're calculated conditions --

MR. LOBEL: Right.

MEMBER KRESS: -- that are intended to have conservatism.

MR. LOBEL: Right.

CHAIRMAN WALLIS: I think that it may be if we were rational, we would look at the statistics of this thing and we would say, "Is that a likely situation at all?" Maybe it's a very unlikely situation.

MR. LOBEL: Well, that's part of my punch line to the talk.

CHAIRMAN WALLIS: Okay.

MR. LOBEL: But basically to answer your question briefly, yes, you aim the analysis in the direction that gives you both. For instance, you assume a break. You assume the distribution of the flow out of the break in a way that gives the minimum pressure in the containment atmosphere and drops the hot fluid directly into the sump so that you maximize the sump. And the more mechanistic --

CHAIRMAN WALLIS: Put all of the heat into the sump, instead of into the container.

MR. LOBEL: Right, that kind of analysis.

CHAIRMAN WALLIS: Okay.

MR. LOBEL: The technical justification is divided into five categories:@containment integrity, will the credited pressure be available; calculation conservatism, confidence that the licensees will not underestimate the NPSH margin and the additional issue of whether there may actually be too much conservatism in these calculations; pump design, what would happen to a safety-related RHR core spray or containment spray pump if the pump were cavitating.

CHAIRMAN WALLIS: Now, when you say "NPSH," do you take this definition that seems to be common of a three percent decrease in head? The pumps might work satisfactorily with a ten percent decrease in head for the purposes of sprays.

MR. LOBEL: Right. That's right. And that's also part of --

CHAIRMAN WALLIS: Also part of your

discussion?

MR. LOBEL: Yes, the experience. And there's been some experience with actual RHR core spray containment spray pumps action operating at --

CHAIRMAN WALLIS: Is that why you have so many slides, because you're going to get into all of this stuff?

MR. LOBEL: Right.

MEMBER SIEBER: Of course, even though most pumps operate in a cavitating mode, when you cavitate to the extent of ten percent, the flow and the head are both down on the pump.

MR. LOBEL: Right.

CHAIRMAN WALLIS: It's a cliff. You go over pretty soon, don't you?

MEMBER SIEBER: Yes. There's a drop-off where everything just quits. You vaporize the fluid to the vortex of the suction, and you just --

MR. LOBEL: What you try to do is you try to operate on what the pump vendors call the knee of the curve before you get the precipitous drop.

MEMBER SIEBER: Right.

VICE CHAIRMAN RANSOM: An interesting point that was made in a recent article was that the most damaging point is between zero and three percent.

MEMBER SIEBER: Yes.

CHAIRMAN WALLIS: But you don't care about damage. You just care about saving the reactor.

MEMBER SIEBER: Well, you do care about damage if you have a mission time and a certain --

CHAIRMAN WALLIS: Yes. It was a certain time. Well, this is probably a slow rate of damage to the pump.

MEMBER SIEBER: Yes.

MR. LOBEL: You have to remember, too -- and I was going to get to this later -- that we're not talking about pumps that are operating for months or years. We're talking about these pumps only having to operate in cavitation for the time that the sump temperature of the sump or the suppression pool temperature is high enough that they get into the problem. But I was going to talk about that more later.

Then I would like to talk a little about the emergency operating procedures, what is the effect on the emergency operating procedures taking credit for containment accident pressure. And then Marty will talk about the risk impact of this assumption or this way of doing the analysis.

The last ACRS letter on this topic stated that "We are concerned, however, with the completeness of the staff's evaluation with respect to the full spectrum of accident sequences." And the staff interpreted this to be beyond design basis accidents.

And the letter went on. "We recommend that future decisions be guided by a more extensive PRA evaluation of the NPSH status for the specific plan of interest over a broader range of accident sequences."

The ACRS also questioned the justification for crediting containment accident pressure in terms of pump degradation due to cavitation and adequate discharge flow. And we intend to address all of these issues today.

Next slide, please.

MR. CARUSO: You've got it there, actually.

CHAIRMAN WALLIS: Hey. I congratulate you, Ralph, on making it work.

MR. CARUSO: Here's your mouse.

MEMBER SIEBER: You can start over now.

CHAIRMAN WALLIS: Do you need ACRS help with this?

MR. LOBEL: Here we go. Okay. I think we're in business again. The original Reg Guide 1.82

was issued in June 1974 and provided guidance on the design of PWR sumps.

Among the positions was a position that blockage of the sump screens should be considered. Fifty percent of the sump screen area should be assumed to be blocked. The flow area should be 50 percent of the total sump screen area. This is still the licensing basis for some plants.

Revision 1 to Reg Guide 1.82 was issued in November 1985. It incorporated the findings from USI A-43 on containment emergency sump performance. The position on screen blockage was revised based on the findings of the USI to the assumption of uniform debris coverage of the sump screen.

Revision 2 to Reg Guide 1.82 was issued in May 1996 and incorporated the work done in investigating blockage of BWR suction strainers.

Revision 3 to Reg Guide 1.82 was issued in November 2003 and incorporated the findings supporting NRC bulletin 2003-01 dealing with PWR sump screen blockage.

As I'll discuss later, revision 3 also incorporated NPSH guidance for safety-related pumps taking suction from the PWR emergency sump or BWR suppression pool.

The revision to Reg Guide 1.82, revision 3, which we're here discussing today --

CHAIRMAN WALLIS: Although, now, I looked at this revision. And there seemed to be a tremendous amount of strike-out. Why is there so much strike-out in this revision?

MR. LOBEL: Part of it was that I noticed when I was going through it that there was some long discussion in both the PWR section and the BWR section that were identical. And so I struck out --

CHAIRMAN WALLIS: So you moved it somewhere else?

MR. LOBEL: -- those and moved it to a place where it --

CHAIRMAN WALLIS: So it hasn't been lost? It hasn't disappeared?

MR. LOBEL: No, no.

CHAIRMAN WALLIS: Okay.

MR. LOBEL: It didn't disappear.

CHAIRMAN WALLIS: I couldn't quite figure out what was going on looking at this.

MR. LOBEL: It didn't disappear. And then as the draft was going through review, different people wanted to make different editorial changes to the reg guide also, some in areas that don't apply to

NPSH, but I think I could say that I believe they were all just editorial changes, just picking a better word and nothing that was a substantive change in any other technical position.

Next slide. Okay. The NRC has allowed credit for the calculated containment accident pressure in determining the available NPSH of the emergency core cooling system and containment heat removal pumps in some BWRs and in fewer cases in PWRs.

We allowed this credit when a conservative analysis has demonstrated that this amount of pressure will be available for the postulated design basis accident and when examined from a broader perspective; that is, beyond design basis accidents, that the level of risk is acceptable. This is the current staff position.

CHAIRMAN WALLIS: That's the current staff position?

MR. LOBEL: Right. And it's really been our position for --

CHAIRMAN WALLIS: You know, we had a meeting on this, which has been quoted several times by folks. In the transcript, it appeared that you didn't have a position at all, that you sort of had some judgment that could be used to give credit when it seemed to be appropriate. There wasn't a specific position which said that these were the comments you had to make.

MR. LOBEL: No, there wasn't, but in doing the reviews, this is pretty much how the reviews were done, not so much the broader perspective but definitely demonstrating conservatism in the calculations that the amount of pressure that was being credited was there based on a calculation that was minimizing the pressure.

CHAIRMAN WALLIS: I thought there was another consideration which had something to do with it being difficult to modify the plant or something like that. Isn't there another -- do you remember that?

MR. LOBEL: Yes. I'm going to get to that in a minute.

CHAIRMAN WALLIS: But that isn't part of this statement you've got here?

MR. LOBEL: No, no. In fact, I think that's coming up.

MEMBER SHACK: It's the second bullet that seems new. I don't think that we've really seen that very much.

MR. LOBEL: The second bullet is new. We

have only recently given a detailed look at risk and beyond design basis accidents. And Marty will talk about that later.

MEMBER SHACK: That seems to be critical. I mean, it's one thing to demonstrate conservatism in a few design basis sequences, but there are lots of other things out there that are going on.

MR. LOBEL: Right. Right. And, actually, as you'll see in a little while, we broke up the risk part of this talk into two parts. And one part talks about the design basis accidents and other accidents and other accidents that aren't considered design basis but that we went through as part of the review, ATWS, appendix R fire, those kinds of things, and the effect that they have in generating debris and in increasing the temperature of the sump or the suppression pool. We did look at those. But we haven't done a detailed look at risk until just recently.

CHAIRMAN WALLIS: While we're talking about debris, debris affects the screen.

MR. LOBEL: Right.

CHAIRMAN WALLIS: But also cavitation is affected by articles in the water, isn't it?

MR. LOBEL: To some more nucleation sites.

CHAIRMAN WALLIS: Doesn't that change the NPSH curves? You've got dirty water. You've got a different NPSH curve.

MR. LOBEL: It theoretically does. I don't know to what extent. I haven't seen any --

CHAIRMAN WALLIS: Dissolved air makes a difference.

MR. LOBEL: Dissolved air makes some difference in --

CHAIRMAN WALLIS: Particulate matter makes some difference. Maybe if you have enough, it doesn't matter how much you have. But I don't know.

MR. LOBEL: I don't know either. I have never seen any data.

CHAIRMAN WALLIS: If you use distilled water, de-gassed, you get a very different answer.

MR. LOBEL: Right. And it's my understanding when the pump vendors derived their required NPSH curves, it's usually done --

CHAIRMAN WALLIS: You use dirty water.

MR. LOBEL: With de-aerated water.

CHAIRMAN WALLIS: De-aerated?

MR. LOBEL: Yes.

CHAIRMAN WALLIS: That's different.

MR. LOBEL: It is different.

MEMBER SIEBER: More severe.

MR. LOBEL: Yes.

CHAIRMAN WALLIS: Because the bubbles push and they collapse.

MR. LOBEL: Right. You put some --

CHAIRMAN WALLIS: But if you're not interested in cavitation damage. You're interested in the effect on head. So you're interested in void fraction in the pump, really. The bubbles make more void fraction. Performance falls off, but the pump doesn't get damaged so much. And you have to separate these two.

MR. LOBEL: See, the guidance on the effect of air hasn't changed. That was addressed back in NUREG 0897. And they came up with a correction factor for the void fraction of air. And that hasn't changed, and the limit is, I believe, two percent of air, volume air.

MEMBER KRESS: On your second bullet, will we find out what your criteria is for an acceptable level of safety.

MR. LOBEL: Well, I'm going to get into that a little later, too, but that gets into the conservatism in the calculation and the use of the required NPSH being equal to the available NPSH, those factors.

MEMBER KRESS: In this assessment, are we concerned with damage to the pump or just loss of head?

MR. LOBEL: Damage to the pump.

MEMBER KRESS: The damage takes place over a time period, and it's --

MR. LOBEL: But it isn't one or the other.

MEMBER KRESS: It's both?

MR. LOBEL: Yes, it's both. You would have to account for both. And the people who have done tests where they have tested a pump in cavitation have measured the drop and looked for damage to the pump itself.

MEMBER SIEBER: But only to the extent that that damage would make the pump inoperable, right?

MR. LOBEL: Right. If the pump keeps pumping, it's not a problem.

MEMBER KRESS: But that was basically my question. Yes.

MR. LOBEL: Like I'll show, the tests that have been done haven't found any damage in the amount of time that the pump has been tested.

MEMBER KRESS: Yes. That was the basis of my question.

MR. LOBEL: Yes. I mean, don't get me wrong. I'm not trying to say that the pump will never be damaged in cavitation. The experience doesn't support making a statement like that. But for the time period that the pumps have been tested, licensees have taken credit for that amount of operation, that time period of operation.

MEMBER KRESS: Well, I'm concerned about the mission time for how long that pump --

MR. LOBEL: And that's why the pump has to remain operable. Mission time can be 30 days or more.

MEMBER KRESS: So you certainly could get damage that would make the pump inoperable in that time frame.

MR. LOBEL: But, again, like I said before and like I'll talk about later, you have to remember that the cavitation time is some shorter amount of time. It's only the time when the suppression pool or sump temperature is high enough that you have cavitation. The rest of the time you're at some higher available NPSH.

VICE CHAIRMAN RANSOM: On your first bullet, there still seems to be some problems in the language. Under 1.311, for example, it states how the containment pressure should be evaluated. And it seems very explicit that it will either be the initial value or based on the vapor pressure of the water at the temperature of the sump.

And then the next paragraph goes on to say that, well, you can. It doesn't say under what conditions. We can talk about that later, but it's as though the one is prescriptive and then the other one says, well -- it doesn't say you can't take credit. It says it may be credited in determining NPSH.

MR. LOBEL: Yes. I had some problem with the wording. And any suggestions -- this is going out for public comment. And hopefully somebody will comment on that.

The idea was that if -- I'm not sure how to word this correctly, but if you're taking credit for containment accident pressure, it's acceptable if you do this conservative analysis.

A lot of licensees still assume only the pressure prior to the accident. And some PWRs make this assumption that the pressure is equal to the vapor pressure at the temperature of the sump water. And what that does, of course, is it doesn't give you any credit for the containment atmosphere. The only thing you're getting credit for is the height of water between the surface and the pump suction.

MEMBER SIEBER: Would that be the case, for example, in subatmospheric containment? How do those kinds of containments treat this?

MR. LOBEL: The subatmospheric containments are a little special. They, I believe, all have taken credit for containment accident pressure since initial licensing because they're starting off at such a low --

MEMBER SIEBER: Yes.

MR. LOBEL: And so the standard review plan says that they can take credit for containment accident pressure during the injection phase of the accident, but during the recirculation phase, they can't.

MEMBER SIEBER: Well, that's the only time when you need it, is during a recirculation.

MR. LOBEL: Well, the problem is in the subatmospheric containments, they start off with a low pressure, of course. And then the pumps that we're really talking about are the recirculation spray pumps.

MEMBER SIEBER: Spray, right.

MR. LOBEL: Initially during a recirculation phase, when you say "recirculation," usually you think of taking suction from the RWST. So this isn't an issue usually.

Some plants are vulnerable at the switchover from the RWST to the sump. When you have recirculation spray pumps like the subatmospheric containment, they're vulnerable from the beginning because you haven't put that much water on the floor yet into the sumps.

MEMBER SIEBER: Right.

MR. LOBEL: And so they need this additional credit. And they have always been given that credit since initial license.

MEMBER SIEBER: In that case, the most severe accident is something smaller than a full guillotine break, right?

MR. LOBEL: I'm not sure. I don't know.

MEMBER SIEBER: The pressure is lower. It takes longer to put water in the sump. Of course, it takes longer to the time when you need to recirculate, too.

MR. LOBEL: Right, right. And one of the conservative assumptions is that you try to get the switchover from the RWST to the sump as soon as you can because that leaves the most water in the RWST and gives you less water in the sump.

MEMBER SIEBER: Yes, but it also gives you less head and higher temperature, --

MR. LOBEL: Right, right.

MEMBER SIEBER: -- which is not good.

MR. LOBEL: Right. Well, yes. All of that is on the conservative side.

MEMBER SIEBER: Right.

MR. LOBEL: You're trying to leave as much water as you can in the RWST so the head is less on the pump.

MEMBER SIEBER: Thank you.

MR. LOBEL: Sure.

VICE CHAIRMAN RANSOM: Rich, are you planning to go through all of these slides or --

MR. LOBEL: I was.

VICE CHAIRMAN RANSOM: -- right now?

MR. LOBEL: Oh. I'm sorry. I was just supposed to do an introduction, wasn't I?

CHAIRMAN WALLIS: That's right.

MR. LOBEL: I got carried away.

MEMBER SIEBER: A pretty good introduction.

MR. LOBEL: I apologize.

MR. CARUSO: I think at the point right now you are on a break point on the regulatory background. How about if we stop here?

MR. LOBEL: Yes. I apologize.

CHAIRMAN WALLIS: While we are on this question of minimizing, albeit conservative, would you accept a submission where what they did was to statistically look at all of the uncertainties in containment calculation and then could convince you that there was a 95 percent probability with 95 percent confidence that the pressure would be bigger than a certain amount? Is that acceptable to you as conservatively minimizing something?

MR. LOBEL: Yes. That is back here somewhere, too.

CHAIRMAN WALLIS: That's in there, too?

MR. LOBEL: Yes. We have had conversations with some people in the industry about doing that, but nothing's come of it yet.

MEMBER SHACK: That's just for design basis accidents, as I understood it, that you really weren't looking over a wider range of sequences that included that.

MR. LOBEL: That would probably have to be for -- well, it wouldn't have to be just for design basis accidents, but it would have to be you would obviously have to be able to define pretty well the analysis so you would know what variables to put in --

CHAIRMAN WALLIS: So we're going to get to that later?

MR. LOBEL: Yes.

CHAIRMAN WALLIS: Okay. So you're going to tantalize us by now going away and coming back later?

MR. LOBEL: Somebody put out the hook. So I'm going for a while.

CHAIRMAN WALLIS: So we have to change gears.

MEMBER SIEBER: So this is for primarily a Bill Sherman presentation, is it, with help from the --

MR. SHERMAN: Both of us.

3. STAKEHOLDER COMMENTS

MR. SHERMAN: Good morning, Chairman Wallis and members of the Subcommittee. I'm Bill Sherman. I'm the state nuclear engineer for the State of Vermont representing the State of Vermont.

We have asked David Lochbaum, whom I think you know from Union of Concerned Scientists, to assist us in some of the workload associated with our concern on the containment over-pressure issue.

I have four preliminary matters that I

would like to mention before I get into the presentation directly. First, with us today in the audience, sitting over here is Sarah Hofmann, the Vermont director of public advocacy; and Mr. Anthony Roisman. Tony is an attorney who is assisting us in our pursuing this issue.

A second preliminary issue is that we have a lot of slides. Our presentation is a little bit long. We think that we've got it timed correctly, and we're going to try and move through it quickly.

Another item, we adjusted our slide show from what we had provided you originally. And I think you have our new slides. The message is the same. We've adjusted it just a little bit, but the message is the same that you saw earlier in the month.

Finally, let's see. Looking on this next slide, the last preliminary item, we're involved in an Atomic Safety and Licensing Board issue related to Vermont Yankee's extended power uprate. However, we recognize that this is a generic meeting. And we're going to speak generically about the over-pressure issue.

There are some places in the presentation that we'll be speaking about examples. We've identified it as the reference plant. There's no mystery the reference plan is Vermont Yankee, but we're using that only as an example.

MEMBER SIEBER: Could you say just a couple of words about the subject matter of the ASLB hearing? What is the issue?

MR. SHERMAN: Our concern was exactly in this area. That is, taking credit for containment over-pressure for demonstrating UCCS pump adequately.

MEMBER SIEBER: Right.

MR. SHERMAN: And we have an admitted contention, which essentially says that the uncertainties are great enough such that over-pressure credit shouldn't be granted. And then, of course, the ASLB process requires lots of work toward proving that.

MEMBER SIEBER: Yes. It's an informal hearing process. I asked the question mainly because I look at things as sort of divided into boxes. You know, there are legal issues, there are policy issues, and there are technical issues.

And even though sometimes the ACRS travels a little bit beyond the boundaries, I think it's important for me to discipline myself to try not to do the job of the ASLB or the commissioners themselves when they endeavor to come up with policy. So it's helpful for me when you tell me where you're interacting and what the issues are.

MR. SHERMAN: It is interesting because from the State of Vermont's perspective, we do not in any way oppose the power uprate. We are concerned about this specific technical issue.

MEMBER SIEBER: Okay.

MR. SHERMAN: So that sort of characterizes where the state is.

MEMBER SIEBER: I'm eager to hear your presentation.

MR. SHERMAN: Thank you.

The next slide is a rough summary of the history Mr. Lobel identified. And I'm not going to spend hardly any time on this slide at all except that for BWRs, there have been two times at the plate to solve the issue: in 1985 and then again in 1995, in the mid '90s.

We think that there are some new issues that affect BWRs now that may require another time at the plate for another slide adjustment. We'll mention those in the presentation.

Next. The next slide is -- we think your current statement on this is from December 12, 1997. There may be others, but in '97, your statement was

"We concur with the NRC staff position selectively granting credit for small amounts of over-pressure in a few cases may be justified."

CHAIRMAN WALLIS: So we are responsible for a statement made by our predecessors, a few of whom may still be around?

MR. SHERMAN: You know, that institutional history is that way. In that same letter, you identified, "We recommend that, instead of using qualitative arguments, restricting attention to a limited range of accident sequences. Decision-making process should consider the time variation of NPSH, broad range of accidents typically found in PRAs.

The current staff guidance we think is the Reg Guide 1.82, rev 3 from November of 2003. We interpret that staff guidance simply. No over-pressure credit should be granted except where needed and where the design cannot be practicably altered. We can point to the lines where they're taking that out in rev. 4 if you like, but that's what we think.

CHAIRMAN WALLIS: The second one is a rather peculiar statement. Does that mean that you can't afford a new pump or something or what does it mean?

MR. SHERMAN: Well, the need and practicably altered, certainly there must be some meaning to that that was intended in rev. 3. And I'm going to speak about that in just a minute.

We wrote a letter in December of 2003, right after the rev. 3 was approved asking about the application of this particular reg guide.

It took the staff six, seven months to answer the state. Basically they identified to us that they weren't following this particular provision of rev. 3. And we're here because we believe that they should have and that they should continue to follow this type guidance.

What we hope to show today, we hope to show today, first, that defense-in-depth should not be compromised by creating barrier dependencies unnecessarily. I think the key word here is "unnecessarily."

The concern, our concern, is not just that the containment might fail, but it's also that the uncertainties are great enough that the NPSH conservatism that is provided, has always been provided, has always been over-pressure, that it ought not to be abandoned again unnecessarily.

While there might be reasons to

selectively grant credit for small amounts of over-pressure in a few cases, you will recognize that as a quote from what we think is your predecessor's letter in '97.

Extended power uprate is a voluntary endeavor that doesn't create a necessity, the obvious that nuclear plants don't need to uprate.

Furthermore, there are practicable alternatives for extended power uprate plants to avoid crediting containment over-pressure.

CHAIRMAN WALLIS: Yes. I was interested in that. I mean, what are these alternatives? Are you going to tell us what they are?

MR. SHERMAN: Yes. In my next slide, it says a word about --

CHAIRMAN WALLIS: You could have an uprate of 20 percent, and you still wouldn't need to credit the containment over-pressure because you have done something else?

MR. SHERMAN: Exactly so. On this side, we have looked at the meaning of need and practicable alternatives. And we actually think its essence is in the backfit rule.

We're not real experts on the backfit rule, but we know that in order to take something that exists and put on it additional requirements there, there is review that must be done according to 10 CFR 50.109.

And over-pressure credit may have been considered necessary in regard to the backfit rule, but extended power uprate does not come under the backfit rule.

MEMBER SIEBER: Right.

MR. SHERMAN: It's voluntary. Now, there's a term of art in extended power uprates called the pinch point analysis, but, simply stated, when these plants do uprate, they go through analysis. And they see that if we change this piece of equipment and spend this amount of money, we can get this increment additional percentage of power. If we commit this amount more money and change this equipment, then we can get additional power.

And as you're familiar with the extended power uprates that had been approved, the percent power on BWRs has gone up to 20 percent. But there have been some that have only been uprated to, I think, 17 percent.

And it's basically an economic analysis that the licensee goes through. And we actually provided you a copy of the reference plant's pinch point analysis.

Unfortunately, the numbers were all blotted out. You couldn't see the cost because that was confidential. But it is a public number that this reference plant has spent over $60 million on equipment changes and other changes, probably closer to 80 or 90 million but at least 60 million.

CHAIRMAN WALLIS: So in the case of, say, a power uprate, you go turbine won't produce the amount of power. Then you have to change the turbine.

MR. SHERMAN: Exactly so. And, as a matter of fact --

CHAIRMAN WALLIS: Because the turbine is a limiting system. Now, in the case of the containment and the pumps and so on, they also may find that they're pushing the limit there, --

MR. SHERMAN: Exactly so.

CHAIRMAN WALLIS: -- which is why NPSH comes into it. And I think you're going to tell us that there are some alternatives to claiming --

MR. SHERMAN: We believe that they have the opportunity --

CHAIRMAN WALLIS: Past that pinch point. They won't be limited by NPSH any more.

MR. SHERMAN: Exactly so. On the

reference plant, they did change out the high-pressure turbine, which cost a number of millions of dollars. And we believe that a properly done pinch point analysis would have identified the necessity for pumps that have different NPSH characteristics, which would not have required containment over-pressure.

CHAIRMAN WALLIS: So you could change out the pumps, then?

MR. SHERMAN: That's what we believe.

CHAIRMAN WALLIS: Okay.

MR. SHERMAN: Before I get into our discussion of uncertainties, let me just make a comment about defense-in-depth. Fundamental to nuclear regulation and nuclear operation is defense-in-depth. Fundamental to defense-in-depth is the three-barrier concept.

When one practices emergency planning drills, one always has in mind the barrier concepts. And the three barriers are the fuel cladding, the reactor coolant pressure boundary, and the containment boundary, any one of which intact prevents radiological consequences, adverse radiological consequences, to the public.

Often in emergency drills and considerations, a loss-of-coolant accident is considered or a small loss-of-coolant accident, even such a thing as relief valves not reseating. And these events, therefore, consider the reactor coolant pressure boundary being degraded. But you have two boundaries that remain: the fuel cladding and the containment boundary.

When you grant credit, -- this is really speaking to the obvious because all of you understand this very clearly -- when you grant over-pressure credit, you are creating a dependency. The fuel cladding boundary depends on the containment boundary.

In other words, with the adverse events that could occur, if the containment boundary fails and you don't have the necessary over-pressure that is credited, then you don't develop enough cooling flow, then that has the potential of damaging the cladding barrier.

CHAIRMAN WALLIS: So you've essentially got one --

MR. SHERMAN: Actually, you --

CHAIRMAN WALLIS: After the LOCA, you've got one difference, which is the containment?

MR. SHERMAN: That's correct.

VICE CHAIRMAN RANSOM: One thing that I don't understand about this in a way is why the containment isn't treated just like any other component in the nuclear power system.

And, in fact, granting over-pressure credit isn't a matter of breaching the containment. It's simply utilizing the pressure, which is going to be there in an accident scenario that you have assumed.

MR. SHERMAN: That's absolutely true, sir. And, yet, in the development of the nuclear industry for the 45-50 years that developed, this defense-in-depth barrier concept with the containment not as a component, like one pump, but, rather, as a significant barrier, has always been significant. You can find discussion of this in the general design criteria.

And so no question that there is containment pressure, but this defense-in-depth concept we think is important.

CHAIRMAN WALLIS: So you're looking at a scenario where the containment boundary fails before the fuel fails, which usually it is the other way around.

MEMBER SIEBER: I think you have to sort of reach beyond the design basis base in order to show a causal linkage between an incident in a plant, like a LOCA or what have you, and the failure containment.

In BWR early plants, the suspected linkage that has been analyzed is the vacuum breakers. On the other hand, you have to assume failures beyond the design basis in order to be able to show or even cause an analysis of the failure of the vacuum breaker to cause this kind of interaction.

So you have to sort of be careful what you're assuming, what actions you're assuming and what failures you're assuming to stay in design basis base, as opposed to severe accidents that are beyond the design basis.

I think that was always -- the big question is, is there some kind of accident that gives you these conditions that is a design basis accident where containment pressure wasn't there to assist in establishing the right --

CHAIRMAN WALLIS: Are there some human actions which somehow bypass the containment that you didn't know about?

MEMBER SIEBER: That's right.

CHAIRMAN WALLIS: Then you had this accident.

MEMBER SIEBER: Right.

MEMBER KRESS: For example, under shutdown conditions, you may have the containment open.

CHAIRMAN WALLIS: Right.

MEMBER SIEBER: Yes.

MEMBER DENNING: And there is also the question if there is failure to isolate the containment. It's not necessarily some severe accident event that caused this failure.

MEMBER SIEBER: Yes. On the other hand, if you're shut down, the energy available to cause the accident is really not there either.

MEMBER KRESS: That's debatable.

CHAIRMAN WALLIS: Unless it goes critical while it is shut down.

MEMBER KRESS: No, no, no. Shutdown risks show that the decay heat is sufficient to cause you severe --

MEMBER SIEBER: Yes. If you can't do anything, if you eliminate all your safety systems, you get heat. Sooner or later, it will get you, but it's slower.

MEMBER KRESS: It's a little slower.

MEMBER SIEBER: Yes.

MR. SHERMAN: I actually have a little bit more to say in this area a little bit later. And we'll get to some more to say in --

CHAIRMAN WALLIS: I think we are following your logic, though.

MEMBER SIEBER: Yes.

MR. SHERMAN: Thank you very much.

I'm sorry. I wanted to point out what I think is a current statement from the Committee again or your predecessors from '99. "The uncertainties that are intended to be compensated for by defense-in-depth include all uncertainties, predictable or unpredictable. Not all of these are directly assessed in the normal PRA uncertainty analysis."

That was true six years ago. We think that is true now, although we're anxious to hear the rest of the staff's presentation because it's possible that they will deal with some of the concerns that we've got here.

Now, the uncertainties are listed on this slide. I'm going to read them all for the purpose of the transcript. We'd like to discuss: One, maximum temperature and minimizing pressure; two, adequate NPSH margin; three, debris head loss; four, required NPSH; five, operator confusion; six, unexpected containment phenomena; seven, inadequacy of the single failure assumption; and, eight, PRA issue of accounting for the unexpected.

We'll be brief with each one of these. We have something to say about each one of them. And we will be brief in doing that.

CHAIRMAN WALLIS: I think neither PRA nor anything else can account for something which you didn't expect.

MR. SHERMAN: Well, we do want to say something about that, sir. So, now, the next part of our presentation, this first one, Mr. Lochbaum will speak on.

MR. LOCHBAUM: Thank you, Bill. Good morning.

The first incident was maximizing temperature and minimizing pressure. The calculations to do so are quite complicated. And evidence has shown that they haven't been done consistently in the past, leading to our concern that the proposed guidances in the draft regulatory guide don't ensure consistency in the future or don't correct the problem that exists.

Slide 14, please.

CHAIRMAN WALLIS: So you are claiming that the calculations can be done in all kinds of ways and still appear to meet the guidance?

MR. LOCHBAUM: That's correct.

CHAIRMAN WALLIS: The guidance says, "You go do the calculation." It doesn't tell you how to do it. So there's a great deal of freedom.

MR. LOCHBAUM: That's correct. That's it in a nutshell.

The next slide, what is in the draft regulatory guide is the factors that can affect the outcomes: Heat transfer to containment structures, containment leakage, containment spray operation, et cetera. All of those are listed in the regulatory guide. There's not much guidance about how do you treat those factors within the calculations.

Next slide. This has been identified in the past in a study done for the NRC in 1997 following the generic letter on NPSH and BWRs. The consultant or the contractor who did the report for the NRC did show after reviewing a number of the calculations that the guidance had not been established. And several utilities were using calculations with assumptions that cannot be justified.

The next slide. For example, this contractor looked at the Duane Arnold over-pressure analysis and found that it was not adequate because the analysis had been overly simplified and did not consider all forms of containment cooling, such as in this case heat transfer to structures in the containment.

Next slide. The contractor also did 11 case studies of containment response. And they varied parameters for each of those 11 case studies, as shown in this table.

The next slide explains what some of those parameters were. The end result or what they ended up doing was comparing the results by varying the parameters. On slide 19, there is a their summary of the results from those case studies.

The point I wanted to make with this slide in this presentation was that by varying the input parameters, which isn't going to be rocket science here, you can have a huge change in the output from the calculations.

And we're not advocating or suggesting that licensees or anybody is out there gaming in order to get the inputs they wanted.

CHAIRMAN WALLIS: This could be the basis of this 95/95 type analysis, where you vary all these things according to some kind of probability. And then you see what's the probability that you fall outside some desired range.

If it's less than something, it might then be acceptable. If this were spelled out, would you satisfy you, then? It's not prescriptive in the sense it's probablistic, but at least it's a prescription for doing a probablistic analysis.

MR. LOCHBAUM: Yes. The goal would be to have a process defined so that if 20 people chose it, so that it would be repeatable and reliable and they would ultimately get the same answer, not be all over the map.

CHAIRMAN WALLIS: So some independent consultant could do the same thing and get the same answer.

MR. LOCHBAUM: Right. We feel the guidance is lacking in achieving that outcome. And, with it, I'll turn it back to Bill for the rest of the --

MR. SHERMAN: The second uncertainty that I mentioned was adequate NPSH margin. There is an ANSI standard that's referred to by the Reg Guide 1.82. We provided you a reference of table 9-611 from that standard, which identified that for nuclear pumps, there is a recommended NPSH margin that's actual over-required of 1.5, a 50 percent margin.

CHAIRMAN WALLIS: I didn't understand

this, 1.5 or 3 feet, whichever is greater. Well, 3 is bigger than 1.5. So what does that mean or does 1.5 go with A and 3 go with R or --

MR. SHERMAN: No. 1.5 is the ratio of the actual over the required.

CHAIRMAN WALLIS: Oh. 1.5 isn't feet? 1.5 is a ratio?

MR. SHERMAN: That's correct. 1.5 isn't.

CHAIRMAN WALLIS: Oh, okay.

MR. SHERMAN: Or three feet, whichever is greater. Sorry about that.

NPSH-r is traditionally defined as the NPSH with a three percent head drop.

CHAIRMAN WALLIS: Could you tell me what A and R mean here because they seem to mean different things in the literature.

MR. SHERMAN: A means the actual.

CHAIRMAN WALLIS: The actual, right.

MR. SHERMAN: And R means the required.

CHAIRMAN WALLIS: R is the three percent drop-off thing. Is that the --

MR. SHERMAN: Yes, sir.

CHAIRMAN WALLIS: Okay. And A is whatever you've got?

MR. SHERMAN: A is whatever you have.

CHAIRMAN WALLIS: All right.

MR. SHERMAN: We provided you with two papers, one by a Mr. Terry Henshaw.

CHAIRMAN WALLIS: 1.5 looks very conservative. Excuse me.

MR. SHERMAN: Yes, sir.

CHAIRMAN WALLIS: Oh, okay.

MR. SHERMAN: A paper by the staff practice. It's pretty conservative. Even more, what we're going to say here, which is we provided you a paper by Mr. Terry Henshaw, a pump expert who identified -- and then we provided comments by other experts on Mr. Henshaw's paper in agreement, which first stated that at NPSH-r, -- that's the three percent head drop -- the pumps are cavitating a lot. And I think that's a common understanding among pump experts.

Furthermore, in order to prevent cavitation, the standard itself says that you need 2 to 20 times NPSH-r to prevent cavitation.

Finally, the statement of Mr. Henshaw is that the actual maximum cavitation point, which was discussed earlier in this meeting, is not below NPSH-r minus three percent, but it's actually between the no NPSH point and the three percent value somewhere. And the experts in these papers agreed with that.

MEMBER KRESS: Pardon me. A question I have about that -- it is probably certainly true and they had good reasons for this happening.

MR. SHERMAN: Yes.

MEMBER KRESS: A question I might have is if you were operating, say, at the peak damage condition, --

MR. SHERMAN: Yes.

MEMBER KRESS: -- how much would that compromise the capability of the pump or its emission time? Would the damage be sufficient so that the emission time is not met where it might be otherwise? Do we have that kind of information?

MR. SHERMAN: Well, that question is exactly our point in that we are presenting this as an uncertainty.

MEMBER KRESS: We just don't know what happens.

MR. SHERMAN: In other words, let me turn it over, the same with the item that Mr. Lochbaum mentioned. There is some probability that the lack of this margin will result in damage. And that probability probably isn't known very well, but it's a real probability which needs to be taken into account in either conservatisms or in PRA space. And we're going to mention both of those here.

MEMBER KRESS: What we know is that the potential for --

MR. SHERMAN: Yes, it's a potential. And, actually, the standard -- you know, the standard, as Dr. Wallis mentioned, you know, the 1.5, that's 50 percent margin. That's quite high. And you're --

MEMBER KRESS: That was the other question I was going to ask. So that gets you above this peak position?

MR. SHERMAN: I'm sorry?

MEMBER KRESS: Will that give you a net positive suction head that's above this peak damage condition?

MR. SHERMAN: According to the experts in the references that we provided you, the answer is yes.

MEMBER KRESS: Okay. That's enough to get you beyond this peak period?

MR. SHERMAN: That was their statement. The statement in their references is that the peak damage is probably a number of percentages above the NPSH-r minus three percent.

Let me show you this slide, which

identifies -- this is from the reference plant. And it will take a little bit of explanation, but I will try and be very brief.

I want to talk about the red line first, the green line next, and the blue line. And so I guess you have to look above to see the color.

CHAIRMAN WALLIS: It's okay.

MR. SHERMAN: The red line is the margin for the reference plant for one of its applications, one of its pumps with its requested over-pressure credit.

CHAIRMAN WALLIS: I don't quite understand. It looks worse than no over-pressure. And I thought having higher NPSH-r margin was good.

MR. SHERMAN: It is. And that -

CHAIRMAN WALLIS: So that they don't credit over-pressure?

MR. SHERMAN: Let me explain as I go through this. The bottom line is the margin with the over-pressure credit that they are requesting. The green line is the margin with their actual situation and their calculated pressure because they're not asking for all of the over-pressure credit. And so when you consider all of their calculated pressure --

CHAIRMAN WALLIS: It gets better.

MR. SHERMAN: Correct. And the top line is what the margin would be if they provided sufficient NPSH without any over-pressure credit.

CHAIRMAN WALLIS: You mean having a different pump?

MR. SHERMAN: Having a different --

CHAIRMAN WALLIS: Something different.

MR. SHERMAN: Or something different.

CHAIRMAN WALLIS: Because if they use the present pump with no over-pressure credit, the curve would be below all of these presumably?

MR. SHERMAN: Correct, without any over-pressure. But I'm trying to give you what the actual situation is.

CHAIRMAN WALLIS: It's interesting to show that, too. So they need over-pressure credit --

MR. SHERMAN: Correct.

CHAIRMAN WALLIS: -- to show what the curve would be because I assumed that this no over-pressure credit was for existing pumps. And I expected to see it below all of the other curves.

MR. SHERMAN: Yes. I see what you're saying. And that curve could have been put on here, but what the no over-pressure credit represents on this graph is if they had --

CHAIRMAN WALLIS: A different pump?

MR. SHERMAN: If they had a different pump that provided the --

CHAIRMAN WALLIS: Screens, different everything?

MR. SHERMAN: Right.

CHAIRMAN WALLIS: Different elevation, had different --

MR. SHERMAN: But the point I wanted to make in words was that at their requested over-pressure credit, they are at a 1.1 margin, which is probably pretty close to the maximum cavitation point or with their real pressure that they've got, 1.2 margin is what it looks like, which, again, is somewhere close or in the range of the maximum cavitation point.

It would be better if they did not have to take credit for over-pressure and this over-pressure remained as an additional conservatism above. Then you have something like the kind of margins that the standard is asking for, at least at the maximum pressure.

MEMBER SIEBER: Why would that be better? Why would that be better? I mean, it's the same pump under the same conditions.

MR. SHERMAN: No. I'm saying that you would need a different pump. And then you would have the over-pressure as a conservatism, not credited but, rather, an extra-conservatism above the --

MEMBER SIEBER: So how did you select the pump that gave you that top curve?

MR. SHERMAN: I didn't select the pump. I only assumed that the pump and the rest of the system, frictions and head losses and so forth, resulted in them having the required NPSH without over-pressure. And then that curve represents the additional margin that the pressure would provide above NPSH-r.

CHAIRMAN WALLIS: So does this go back to your earlier argument that there was an alternative design which would get them past this pinch point --

MR. SHERMAN: Yes, sir.

CHAIRMAN WALLIS: -- without getting any credit for over-pressure?

MR. SHERMAN: Yes.

CHAIRMAN WALLIS: You're saying what they should do is spend money on a pump, rather than spend money to NRC?

MR. SHERMAN: I believe what we're saying is that we don't think that this reduction in conservatism should be done unnecessarily.

CHAIRMAN WALLIS: But you're saying that there is an alternative?

VICE CHAIRMAN RANSOM: Is there something that characterizes that particular pump that you selected? I mean, presumably there would be a range of NPSH capabilities at different pumps. It seems to match at the end of the 55.6 hours. I'm just wondering if there were some criteria or what criteria was used to select that pump.

MR. SHERMAN: The pump in the example is the 30-year-old pump that has been used for this application from the beginning. And then there have been many changes over the 30 years: sump strainer redesigns, sump clogging issues.

Well, actually, my next point will say more, but go ahead. Ask --

VICE CHAIRMAN RANSOM: Is this the same pump you're saying, you're addressing now?

MEMBER SIEBER: No.

MR. SHERMAN: Oh. What you're asking is what the characteristics would be of a new pump?

VICE CHAIRMAN RANSOM: Right. Why couldn't I select just a wide variety of pumps? I mean, what criteria is used to specify how much increase in NPSH margin was demanded of that pump, I guess?

MR. SHERMAN: In basic engineering and with this situation 30 years ago, one looks at what the system requirements are and then one goes to pump manufacturers and finds a pump that will meet those requirements.

In the situation that they have, as I'll show in the next slide, they have higher temperatures in the sump. The torus water has higher temperature. That creates an additional requirement for NPSH. They would need to select a pump which had different NPSH requirements that met the new requirements.

VICE CHAIRMAN RANSOM: What criterion was used? I mean, how high is good enough?

MR. SHERMAN: Thirty years ago the torus temperature wasn't as high.

VICE CHAIRMAN RANSOM: Well, is this 30 years ago, this pump?

MEMBER SHACK: I think the line is the credited over-pressure pump. Now, as I understand what you're arguing, you picked the pump that was one with no over-pressure credit. And then that no over-pressure line is the actual NPSH margin you have with the pressure. Is that --

MR. SHERMAN: I didn't really pick a pump. I only assumed that the pump and system had --

MEMBER SHACK: The one.

MR. SHERMAN: -- NPSH-r. In other words, the calculation resulted in the required NPSH to show you what additional margin over the containment pressure would provide if the system already had NPSH-r.

MEMBER KRESS: That means you started this curve at times zero at a ratio of one.

MR. SHERMAN: Correct.

MEMBER KRESS: What Bill was saying.

MR. SHERMAN: Correct.

MEMBER KRESS: And the rest is just the temperature and pressure you get.

MR. SHERMAN: That's exactly it. Yes, sir.

MEMBER KRESS: During the actual --

MR. SHERMAN: Yes.

MEMBER KRESS: The question is, what accident are we dealing with here? Is the design basis the worst one or --

MR. SHERMAN: This is actually the design basis LOCA. And you're right. I did not specify that.

MEMBER KRESS: This is for the design basis LOCA?

MR. SHERMAN: Yes, sir.

MEMBER KRESS: Okay.

MEMBER SIEBER: The curves that represent the so-called new pump, they actually don't represent a physical pump that you could go out and buy.

MR. SHERMAN: That's correct.

MEMBER SIEBER: And, in fact, there probably isn't such a pump that would give you these numbers unless you changed the entire design envelope, which means put the pump deeper in the ground to provide additional head and so forth, which typically is either impossible or inordinately expensive to do. We're really talking about a hypothetical pump here.

MR. SHERMAN: That's correct. And, as a matter of fact, in other space, in the legal space that you asked me about earlier, we have asked them, have they done an evaluation and what costs they had for pumps that would meet that. And the answer that we had at that point was that they had not done that. So they had not looked to see if they could. And we think that's what the situation is now with the reference plant.

We don't want to get -- may I go on to the next uncertainty?

MEMBER SIEBER: Thank you.

MR. SHERMAN: We believe that there is also an uncertainty with head loss. As a matter of fact, you have dealt with that a lot. And Reg Guide 1.82 deals with that directly on point.

I thought it would be interesting again to provide a sample calculation from the reference plan to give you order of magnitudes. The NPSH-r for this particular application -- it is the same one that was graphed before -- is about 32 feet.

I've given you the calculation at 170 degrees Fahrenheit and the calculation at 195 degrees Fahrenheit torus temperature. Actually, 195 is their maximum calculated torus temperature.

You can see a number of things from this calculation. Number one, you can see that at 170 degrees Fahrenheit, they almost have sufficient NPSH-a without having to credit over-pressure. 29.17 feet is close to 32. They need a little bit of over-pressure, a credit at 170.

CHAIRMAN WALLIS: Doesn't this 32 feet depend on temperature? The NPSH-r must be a function of temperature?

MR. SHERMAN: It is, but it is not

generally adjusted for temperature.

CHAIRMAN WALLIS: Well, if the temperature were boiling point, presumably it would be zero.

MR. SHERMAN: The NPSH-r is a function of the pump and system. You know, the actual depends on temperature, but what you have to develop, there is a relationship to temperature, but it's not credited.

CHAIRMAN WALLIS: That seems very strange. I would think that NPSH-r must depend on temperature. Why is the pressure head so different at these two conditions here?

MR. SHERMAN: The pressure head is different. And that's one of the things that I wanted to show in this, that the whole reason for needing over-pressure credit is because of the increase in temperature. You can see that at the higher -- basically it's because the density of water is less at higher temperatures.

CHAIRMAN WALLIS: It doesn't change very much, though.

MR. SHERMAN: But in the calculation, it does. And you can see that the increase in temperature from 170 to 195 actually reduces the actual NPSH by about a third, from roughly 30 to roughly 20.

And, therefore, what you're asking for at the maximum situation is about -- you're asking for over-pressure credit to make up about one-third of your actual NPSH.

CHAIRMAN WALLIS: What is this pressure head term here? I don't quite understand there.

MR. SHERMAN: Well, I probably should have made a slide that shows it, but it's actually the atmospheric pressure minus the vapor pressure.

CHAIRMAN WALLIS: So that's where the temperature comes in?

MR. SHERMAN: Yes, it does. At times the specific --

CHAIRMAN WALLIS: Okay. Okay. So that's assuming the containment is at atmospheric pressure?

MR. SHERMAN: That's correct. This does not assume over-pressure.

CHAIRMAN WALLIS: Okay. And the debris loss is not a contributor here?

MR. SHERMAN: That's the other point that I wanted to show you for the reference plant, that the debris loss term is almost negligible. It's only a third of a foot in the calculation.

Let me move on. My point with this is that in this area, the debris head loss term, which in the reference plant I showed you was very small, there is uncertainty. There is some probability that that is not the right value and that it is going to be more.

I've listed on the slide four things, which I'll just say real quick. But you know this from the work that I have seen in your transcripts. You know that the research in translating the research into equations and methods, there are many, many assumptions that are used. The assumption of --

CHAIRMAN WALLIS: That's separate from the NPSH question. If you have enough debris, you clog the screen. And the pump can suck as much as it likes. It's not going to get much closer there.

MR. SHERMAN: But, as you see, you know, in the calculation for the record for this example, they are not showing much head loss. And our overall point is that there is some probability, whatever it is, that that head loss term is too low and that it should be higher or might be higher.

Homogeneity is a big assumption, you know, assuming all the debris is similar size particles and all mixed evenly and all deposited evenly. That's a huge assumption.

CHAIRMAN WALLIS: So did you look into

this? Did they compute this using the present regulation, which is 50 percent at the screen as clogged? Is that --

MR. SHERMAN: No, no. They used the head loss correlation from NUREG --

CHAIRMAN WALLIS: Did they assume that the screen was then clogged uniformly or 50 percent? Fifty percent is the present rule I understand.

MR. SHERMAN: I think uniformly.

CHAIRMAN WALLIS: Uniformly?

MR. SHERMAN: Uniformly.

CHAIRMAN WALLIS: Okay.

MEMBER SIEBER: And that's actually the worst case, right, because if it's not uniformly, then there are places where the flow can --

CHAIRMAN WALLIS: It's uniformly over the screen but not necessarily within the bed. You know, there's this steam bed business and all that stuff.

MR. SHERMAN: But that's just the question. Yes, probably the worst case, although you have got little bits of foil that are down there. And there are assumptions about what happens with this foil. You have got all manner of -- you've got this huge conflagration going on. And there are just many assumptions.

But one particular assumption I have listed here is the reference plant paint chip assumption. In the specific case of the paint chips in this plant, they assumed that all of the unqualified paint in containment fails. They assumed that all of the unqualified paint is transferred to the torus. They assumed that no paint chips are deposited on the strainer. And they do that. They --

CHAIRMAN WALLIS: What goes through the strainer?

MR. SHERMAN: No. It all settles on the floor.

CHAIRMAN WALLIS: The floor. I see.

MR. SHERMAN: And the assumption is based on Ogden Research Lab tests. So that they have done what is prudent for plants to do. They have done testing.

Our point is that there is some probability that that is not right and that somehow that probability of that not being the best assumption needs to be considered. It's an uncertainty. And we're going to say more about it when we get to the end. We can go faster.

MEMBER SHACK: The reference plant would probably argue that that debris loss is conservative.

They would not argue that it is accurate.

MR. SHERMAN: Well, heat is probably right. Yes, sir. Yes, sir.

CHAIRMAN WALLIS: Do you know how much of the paint is unqualified? Is this all of the paint in the containment?

MEMBER SIEBER: No.

MR. SHERMAN: I would have to do research, but, to the best of my knowledge, the top coat is unqualified. And there is a certain percentage of it left. A lot of it is peeled off already.

The bottom coat adheres. The primer coat adheres. But I'm doing that from memory.

MEMBER SIEBER: That is an epoxy paint?

MR. SHERMAN: Yes. My next item, I'm going to try and go a little bit faster. My next item has to do with required NPSH itself. It turns out that in the reference plant, the witness pump tests for the reference plant 30 years go.

Well, things were different 30 years ago or 40 years ago. And so they weren't run long enough. They didn't take vibration readings. They weren't done in exactly the ranges that they're operating now.

And so it turns out that to get an NPSH-r, they have had to go back and sort of rebuild this. In rebuilding this, they have had to do a lot of extrapolation for areas where they didn't have that.

I'm not questioning pump science. I think the extrapolation methodologies are correct. They have had to use as a basis not the pumps from their own plant but pumps from other plants where they had had data, pumps that didn't even run at the same speeds, which meant that they have had to adjust the speeds.

My only point here is that in the NPSH-r that they're using, there is some uncertainty or question. There is some probability that that is not adequate and that what they developed is not the right one.

MEMBER SIEBER: Just for my own information, the reference plant, what was its commercial operation date?

MR. SHERMAN: Nineteen seventy-two. Construction permit, '68; operation, '72.

MEMBER SIEBER: Okay. I'm just trying to think of what the testing programs were. Plants in that time frame used to run 30-day tests.

MR. SHERMAN: Well, that's one of the difficulties, that these pumps weren't run very long at each point enough to really see that the data had

--

MEMBER SIEBER: That's all they did, get a head loss curve?

MR. SHERMAN: Yes, that's correct.

MEMBER SIEBER: But not a duration curve?

MR. SHERMAN: Correct.

VICE CHAIRMAN RANSOM: Are these the original head flow tests --

MR. SHERMAN: Yes.

VICE CHAIRMAN RANSOM: -- that were made with the pumps?

MR. SHERMAN: Yes, sir.

VICE CHAIRMAN RANSOM: Those are the ones that we have which are the graphs which are difficult to read because of the --

MR. SHERMAN: Yes, that is correct.

VICE CHAIRMAN RANSOM: -- black background and --

MR. SHERMAN: Yes. We provided you that as one of the references we provided.

CHAIRMAN WALLIS: So I think what you are saying is there are quite a few uncertainties here which you don't think are being suitably taken into consideration in whatever the plant is claiming?

MR. SHERMAN: Yes. And we are going to

show that on a graph. And we are going to conclude that we shouldn't give away the credit unnecessarily.

CHAIRMAN WALLIS: So if they did this, if they actually did a more sophisticated analysis and put in uncertainties and all of that stuff, they might come up with something acceptable there?

MR. SHERMAN: Or it might clearly state that we ought not to give this --

CHAIRMAN WALLIS: It might. It might reach a negative conclusion. Sure.

MR. SHERMAN: That's what we think.

CHAIRMAN WALLIS: All right.

MR. SHERMAN: Number five is operator confusion. When you grant over-pressure credit, we think you create a human factors problem because we all know that in the type of accidents that are considered, one of the primary functions of the operator is to reduce containment pressure, to reduce leakage. And operators have trained and trained and trained on that.

And now what you do with over-pressure is you're telling the operator, "Do that, but, on the other hand, make sure that you save some containment pressure because we're taking credit for it."

MEMBER SIEBER: This might be in using

containment sprays, for instance, if they were installed.

MR. SHERMAN: Right.

MEMBER SIEBER: I don't know if this is a different sort of -- in some plants, perhaps not this one, there would be containment sprays.

MR. SHERMAN: There are sprays in this plant. And we spoke with the reference plant. And they identified to us that they did not intend to change their emergency operating procedures based on containment over-pressure credit.

What we expected to see is some statement in the EOPs that said "Assure that for this period you keep this amount of pressure," but they don't do that. What they do is they operate on a family of curves for each of the pumps in question.

And the family of curves basically has containment pressure plotted against some temperature. And the family of curves is flow curves such that given the pressure of the containment and the temperature of the sump, you can see an acceptable GPM flow rate from the pumps.

Now, our concern is this. We think that the operators have pretty fine control over the pump flow rates. We think they have much less fine control of the containment pressure. But what they're asked to do is they're asked to reduce pressure just right and then stop it at the right flow.

But what we think is more likely is that they are going to reduce pressure and then they're going to get to a point where they turn off the sprays and pressure is going to go somewhere, likely below where they need. And then in order to keep the pump in range, they're going to have to reduce pump flow --

MEMBER SIEBER: Yes.

MR. SHERMAN: -- and in reducing pump flow, have less flow than is credited in the accident delivery analysis. Our only point here is that there is a probability that the operators won't do this right. And we think that it is a probability that is higher than just the regular human factors probabilities because of the confusion that is incorporated in this. It is one of the six uncertainties that we have for you today.

Yes, sir?

MEMBER SIEBER: You can help me make sure that I have this properly in my mind. In order for me to explain what I think is going on, you have to make an assumption that everything is sort of homogeneous inside containment.

It would seem to me that if you reduce containment pressure, you do it by cooling the vapor in containment.

MR. SHERMAN: Yes, sir.

MEMBER SIEBER: And, as you cool that vapor, you're reducing the temperature of the water in the sump. Otherwise, it would boil and keep the pressure up.

And so the pressure that contributes to NPSH is declining as the operators are cooling off containment, but, at the same time, the sump water is also declining, which makes it less critical from the standpoint of required head for that pump to operate.

Doesn't that all sort of balance out? And the only real sticker is the assumption that everything is a so-called equilibrium, which probably is the case because, you know, it's a saturated system?

MR. SHERMAN: Two comments, sir.

MEMBER SIEBER: Okay.

MR. SHERMAN: Comment number one is --

MEMBER SIEBER: Help me out.

MR. SHERMAN: The simplest answer is yes. But the two comments are it depends on where you are. I mean, it depends on where the temperature starts.

If the temperature is high, granted, you're coming down with containment pressure, but obviously that temperature is high enough such that in some calculations, they needed to ask for containment over-pressure credit.

So, stated simply, in some space, the power uprate, the addition of power that is produced, has created a higher temperature that has brought all of this up higher than it was previously. And, therefore, we're in an area of concern.

And then the second thing is that there probably is a lag between containment pressure and sump temperature drop in torus water temperature.

So it probably doesn't track exactly one to one. There's probably some physical time lag.

MEMBER SIEBER: I would imagine. Yes. That's why I said that equilibrium had to be an assumption.

MR. SHERMAN: Yes.

MEMBER SIEBER: You know, it probably doesn't exit, particularly in BWRs because the containment is sort of complex in the BWR from the standpoint of --

MR. SHERMAN: The dry well is up there and --

MEMBER SIEBER: Yes. Intercommunication of various parts of the containment. Okay. That answers my question.

CHAIRMAN WALLIS: So what you are really saying is that depending on what the operator does, these curves are pressure and temperature. And NPSH vary with time over days maybe.

MR. SHERMAN: Yes, although one point I didn't exactly state before is that the reference plant is asking for over-pressure credit for the -- I showed it on one early curve -- for 55 hours. So in this situation, they are asking for --

MEMBER SIEBER: For how long do they need it?

MR. SHERMAN: Fifty-four hours.

MEMBER SIEBER: For 55 hours?

MR. SHERMAN: More than two days.

MEMBER SIEBER: Okay.

MR. SHERMAN: More than two days of run.

MEMBER SHACK: But, again, just to address your point, I mean, it's not really surprising that there's no change in EOPs. Even if they don't get credit for containment over-pressure, they've been trying to maintain it.

MR. SHERMAN: Well, the family of pump

curves exists. And they exist in current EOPs. The necessity for over-pressure credit, as I say, just raises you up on that curve and makes it more critical.

And I do believe that it is more likely -- I need to say it differently. There is a probability that the operator will not be able to catch the containment pressure at the level he or she needs such that they would need to reduce pump flow in order to stay within their family of curves.

And my only point is that that probability needs to be taken into account. We'll get to the graph that shows that here.

MR. LOCHBAUM: I just want to add one brief comment in that while it's true that they may have been always wanting to maintain it, now power uprate might impose a consequence if they don't maintain it that wasn't there before.

So the EOP should address that so the operator doesn't inadvertently wander into some space that they should not be. So that's why the expectation was that the EOPs would address that new need or new precaution.

CHAIRMAN WALLIS: So you're saying they control the pump flow rates in response to the pressures and temperatures. So to avoid cavitation, they might reduce the pump speed?

MR. SHERMAN: Yes, pump speed.

CHAIRMAN WALLIS: What would they do?

MEMBER SIEBER: Not the speed.

MR. SHERMAN: I'm sorry. They would control it with valves.

CHAIRMAN WALLIS: With valves?

MEMBER SIEBER: They throttle the discharge.

CHAIRMAN WALLIS: They throttle the discharge. Okay.

MEMBER SIEBER: Yes.

CHAIRMAN WALLIS: But the speed is still the same?

MR. SHERMAN: Yes, sir.

MEMBER SIEBER: It's a regular --

CHAIRMAN WALLIS: If you shut down the pump and run it, it cavitates merrily. It boils in the pump if you shut --

MEMBER SIEBER: It shouldn't. The pump is probably the lowest point in the system. There may be boiling going on someplace.

CHAIRMAN WALLIS: There's no flow through it. It just heats the water until it --

MEMBER SIEBER: If the pump is shut off, it is not going to boil there. If the pump is running but the discharge valve is closed, it will boil.

CHAIRMAN WALLIS: That's right. That's what I mean.

MEMBER SIEBER: Okay.

CHAIRMAN WALLIS: So a lot of things are interwoven here.

MR. SHERMAN: These last three are very quick.

CHAIRMAN WALLIS: So he might throttle the discharge, then, if he was approaching cavitation? And then you're saying this might not cool the coil sufficiently?

MR. SHERMAN: Well, I believe that in this regime, the attempt would be to control according to containment pressure.

CHAIRMAN WALLIS: I think it's much more important to cool the coil than to try to avoid some minor cavitation damage to the pump.

MR. SHERMAN: Well, that's another issue.

MEMBER SIEBER: The difficulty is that the operator can't go and look at the pump or see it or hear it, you know, because if you had an accident, that whole area --

VICE CHAIRMAN RANSOM: I thought the main issue was inadequate cooling, not damage to the pump, because even if you go beyond the three percent, there's less --

MEMBER SIEBER: Up to about three percent.

VICE CHAIRMAN RANSOM: -- probability of damage to the pump but --

MEMBER SIEBER: You're probably okay. And I agree that a little bit of cavitation can sometimes be worse than more cavitation because it kills the bearings. It knocks the seals. And so you may end up with a pump that leaks, which is not a good idea if it's pumping radioactive water.

On the other hand, it will still pump. It takes a fairly long period of time before you do damage to the impeller to the extent that the pump won't run or it won't pump.

VICE CHAIRMAN RANSOM: So the main concern, I guess, is loss of head, right? Inadequate cooling?

MEMBER SIEBER: Well, once you run beyond the need of the curve, then the pump stops pumping at all.

VICE CHAIRMAN RANSOM: Right.

MEMBER SIEBER: And it may chug. It may

quit. And then damage occurs very rapidly because you're pouring a lot of --

VICE CHAIRMAN RANSOM: Well, that's not what I read in those articles that you provided. As a matter of fact, they said, you know, if you run beyond the three percent point, that the pump has no problem with that.

MEMBER SIEBER: Well, the pump --

VICE CHAIRMAN RANSOM: Basically it's more or less like homogeneous --

MEMBER SIEBER: Pump about ten percent, but there comes --

VICE CHAIRMAN RANSOM: Right. The head is down.

MEMBER SIEBER: Yes. There comes a point where it won't pump at all and you get basically a void at the vortex of the suction. And, you know, there's just no way to move the fluid through it. But that's well beyond the low NPSH values that the required values are set.

MR. SHERMAN: It's interesting because on the reference plant that we're speaking about, they actually don't use the NPSH-r as the three percent value.

What they end up using is a curve from the pump vendor that says that from zero to seven hours, you can operate at this NPSH. And it will be satisfactory. In other words, that takes into account what you're saying about --

MEMBER SIEBER: The damage.

MR. SHERMAN: And the zero to seven-hour range is less than NPSH minus six percent. So it's down lower.

MEMBER SIEBER: Yes. Those kinds of vendor statements are not unique to the reference plant.

MR. SHERMAN: Correct. That's exactly -- and that's our point. And for the long term, they are given another value that is a little bit higher than NPSH minus three percent. Actually, it looks to be close to the maximum cavitation point.

But they're given a vendor statement. And presumably there is vendor information which backs this up, though we haven't seen it. Presumably it exists. I don't know if the staff has seen it, but on the reference plant. Presumably that type of data exists.

MEMBER SIEBER: Well, I don't --

CHAIRMAN WALLIS: There are at least four parties involved here. There's you. And then there's the licensee, and there's the NRC. And there's us.

You're raising all of these questions. I would think they could be answered by the licensee. Are you telling us that you're not getting satisfactory answers from Vermont Yankee? Is that what you're telling us?

MR. SHERMAN: I'm not making any statements around in that area.

CHAIRMAN WALLIS: Do you see? I mean, it seems sort of strange. Are you asking us to ask Vermont Yankee these questions? Are you asking us to ask the staff to ask Vermont Yankee or what?

MEMBER SIEBER: I think that's the only path they can do.

MR. SHERMAN: No, sir. No, sir, not at all. We are here to demonstrate that these are uncertainties that exist in the particular plant we have looked at.

CHAIRMAN WALLIS: I would say go away and resolve them, you know. Tell us when it's sorted out.

MEMBER SIEBER: The only way that these folks can talk to the licensee is through the staff. They can't do it directly.

CHAIRMAN WALLIS: They can't?

VICE CHAIRMAN RANSOM: We're dealing with

Reg Guide 1.82, --

MEMBER SIEBER: It depends on what their --

VICE CHAIRMAN RANSOM: -- I think. And so what you're concerned with is there may not be a prescriptive enough way of dealing with the uncertainties?

MR. SHERMAN: That is exactly it. We feel that these uncertainties exist. But let me run through these last three. And then I'll make that --

CHAIRMAN WALLIS: I guess we are talking about 1.82, right? 1.82 has a litany of things that thou shalt consider, but it doesn't tell you how to do it.

MR. SHERMAN: Exactly. I have an uncertainty here of unexpected containment phenomena. The reason that we put this in is this exactly ties to the defense-in-depth. This is the one where the containment doesn't function the way you expect.

Since, in addition to these considerations, you are very much aware that the containment leak test frequency is much less than it used to be, it used to be every other outage, now it's every ten years, the reference plant I think has a waiver to go 15 years. And that changes your probability function based on the extension of the test frequency.

MEMBER SIEBER: What function are you talking about?

MR. SHERMAN: Well, I'm talking about whatever the probability is that there is some leakage that you don't know about.

MEMBER SIEBER: Yes, but that doesn't impact the way the pump operates. That impacts --

MR. SHERMAN: If you give containment --

MEMBER SIEBER: -- Part 100.

MR. SHERMAN: No. If you give containment over-pressure credit, it does because you're relying on --

MEMBER SIEBER: You would really have to leak a lot.

MR. SHERMAN: Well, the amount of leakage and whether it affected the overall pressure is an issue, you know.

MEMBER SIEBER: Yes. But, like I say, that would not be your first concern that you're losing. Your first concern --

MR. SHERMAN: Would be radiation.

MEMBER SIEBER: Radiation?

MR. SHERMAN: Radiation. But I wanted to

point out the specific reference plant issue related to the main steam isolation valves. In the last five outages at the reference plant, they test all eight main steam isolation valves, each outage.

MEMBER SIEBER: Right.

MR. SHERMAN: And, therefore, in the last 5 outages, that would be 40 valve tests. In those 40 valve tests, they've had 10 valve failures, 10 MSIV failures.

CHAIRMAN WALLIS: What do you mean by "failure"?

MEMBER SIEBER: Excess leakage, right?

MR. SHERMAN: Excess leakage.

CHAIRMAN WALLIS: Do you mean that there's a leakage in the pipe? It's not to the outside world?

MR. SHERMAN: Correct.

CHAIRMAN WALLIS: It just flows through the valve when it's -- it's set to the flows, but there's a flow-through in it.

MR. SHERMAN: Correct. Some of the failures were failures to -- they did pressurize, but the leak rate through them was higher than allowable. But there were others of these failures where they wouldn't pressurize.

MEMBER SIEBER: They wouldn't pressurize

at all?

MR. SHERMAN: To the best of my knowledge, there was at least one that was in that category, maybe more. I'm not sure. I'd have to look at the --

MEMBER SIEBER: I'll have to --

MR. SHERMAN: I provided the reference to you.

MEMBER SIEBER: All right.

MR. SHERMAN: My point is that this is a particular feature. This is a particular attribute of the reference plant. But there may be other situations out there like this.

MEMBER SIEBER: Well, so when you call out the main steam isolation valves, that's not a containment boundary for this plant. You call it out by analogy that if this leaks, something else must leak or explain to me how I'm to draw a --

CHAIRMAN WALLIS: Isn't it a containment in a BWR? What is the --

MR. SHERMAN: It is a containment boundary in the BWR in that if you have a loss of coolant accident, then you have --

MEMBER SIEBER: It's supposed to close, yes.

MR. SHERMAN: -- then you have an open

pathway. And if the valves aren't failing, then you have an open pathway of the containment atmosphere.

MEMBER SIEBER: Right, yes.

MR. SHERMAN: Number seven has to do with deterministic calculations. It has to do about the single failure assumption. I go way back in the nuclear industry, all my working career.

The single failure assumption has been in my view the backbone of nuclear design. That's why we have redundant systems. And it's why we have such a good safety record for the nuclear industry.

But when you get to calculations like we're talking about here, the single failure assumption has a detriment to it. And that is that when real transients occur, David and I had a difference in discussion. You know, I think about one out of three transients, you have more than one failure. David said one out of two. But, at any rate, the real history of transients is that you get more than one failure.

You add that to the emergence, at the bottom bullet point, of what is called LCO, or online maintenance. As you know, in these later years, all the nuclear plants are intentionally taking out safety-related equipment to do maintenance for up to a period of a week or so.

As a matter of fact, in the recent Fitzpatrick event, which you're probably aware of, with its torus, the diesel generator, one diesel generator, was out when that was discovered, I believe.

My only point here is that when you're doing calculations like the calculations that Mr. Lochbaum spoke about, maximizing temperature, minimizing pressure, you assume the worst single failure. But there's a sort of a non-conservatism in that assumption because there is some possibility that you're going to get more than one failure.

MEMBER SIEBER: But the design basis and the licensing basis require you to assume an act of failure along with whatever passive failure caused the event.

MR. SHERMAN: Passive failure to cause the event and then --

MEMBER SIEBER: And so the way you assure yourself beyond the design basis is to look at the probabilities of multiple failures through PRA and not --

MR. SHERMAN: Well, that's exactly where I was going with the next slide.

MEMBER SIEBER: -- cause risk, additional risk.

MR. SHERMAN: In other words, what has happened is that to answer this question about more than one single failure with deterministic calculations, --

MEMBER SIEBER: Well, you can't.

MR. SHERMAN: -- we go to PRAs.

MEMBER SIEBER: Well, it's no longer deterministic when you do that.

MR. SHERMAN: Correct.

MEMBER SIEBER: The deterministic thing says, "Here is what you are required to assume." And then you go and get the answer and see if it's a good answer or a bad answer. Once you go beyond the design basis, you will get it in terms of risk probabilities.

MR. SHERMAN: Exactly so. And let me --

MEMBER SIEBER: You're going to go through there anyway.

MR. SHERMAN: We're going to jump right there. With PRAs, the hard part about PRA that Chairman Wallis and I -- we had an exchange just a minute ago. It's the uncertainty. It's the unknown. How do you model Davis-Bessee in the PRA? How do you model this sump/strainer history that you've had where, you know, you --

CHAIRMAN WALLIS: After it has happened, you can model that.

MR. SHERMAN: There you go. After it has happened, you have a pretty good failure rate after it happens.

MEMBER SIEBER: Well, in general, it was always in there. You know, they assumed LOCA. The question is was the --

MR. SHERMAN: What caused it?

MEMBER SIEBER: The failure probability, was that correct or not? You know, when the failure probability approaches one, I think you have got a different kind of an issue going.

MR. SHERMAN: So here is what we are trying to say. We're trying to say that the uncertainties that we have identified are real uncertainties. From a deterministic point of view, the uncertainties are great enough to direct that over-pressure should be retained along with the other conservatisms associated with deterministic methods.

In PRA space, we feel that the PRA doesn't adequately account for the uncertainties that we have described and that we feel that if they did, we feel that they would direct you to retain the over-pressure conservatism, rather than give it away.

CHAIRMAN WALLIS: Now, when you say over-pressure should be retained, you mean that there should be no credit for over-pressure. Is that what you mean?

MR. SHERMAN: That's correct.

CHAIRMAN WALLIS: Is this --

MR. SHERMAN: The system should provide sufficient NPSH without having --

CHAIRMAN WALLIS: Without taking credit for --

MR. SHERMAN: -- credit for the containment pressure.

MEMBER SIEBER: And the effect of that is to set a limit on how much power the reactor should normally be licensed to produce.

MR. SHERMAN: No, not necessarily.

MEMBER SIEBER: Or buy new pumps.

MR. SHERMAN: Or buy new pumps. But we think --

MEMBER SIEBER: If you can.

MR. SHERMAN: Exactly so. Exactly so, if you can.

MEMBER SIEBER: Okay.

MR. SHERMAN: Now, looking at PRA space,

I've provided here a fault tree for containment isolation failure. I'd like to look at three things in the fault tree.

I know it's hard to read. And the first one is containment isolation failure, the top line of the item. I think that it needs to be identified as containment fails to hold pressure, which may be the same as containment isolation failure but may not. And I think that a thorough evaluation of the fault tree may flush out some areas where they're not exactly the same or they may not. I just don't know.

CHAIRMAN WALLIS: Let me try to see what you're thinking about. I could see a situation -- maybe this isn't realistic -- where you have a LOCA and you have no fuel failure. So there's no radioactivity. And then your containment fails to hold pressure, and the fuel fails later in this scenario as a result of insufficient cooling because the pumps don't work. Is that what you're looking at?

MR. SHERMAN: Right, right.

CHAIRMAN WALLIS: So you could have a failure to hold pressure, which initially doesn't involve any failure to contain radioactivity because there isn't any.

MR. SHERMAN: Correct, right.

CHAIRMAN WALLIS: Okay.

MR. SHERMAN: The next item on here, I've circled the "dry well isolation failure flow path," two-inch diameter or greater. When we looked at the fault tree and tried to understand this, it did not look like this included MSIV or feedwater failure for the reference plant.

We have already pointed out that the MSIV failure rate at this particular reference plant is high, higher such that we think that the result that this fault tree is given is probably an order of magnitude too low, considering the MSIV failures.

CHAIRMAN WALLIS: Well, this is all qualitative. Has anyone calculated? Maybe they don't know the leak rates of the MSIVs. But if you know the leak rates, you could presumably figure out the rate of --

MR. SHERMAN: Well, we think maybe the staff will have something for us. We hope so.

CHAIRMAN WALLIS: The staff is going to do that?

MR. SHERMAN: We hope.

MR. LOCHBAUM: I also, if I could just have a minute, think that's related to Bill's comment about what the criterion is. If it's containment isolation failure, then it's go/no go. If it's failure to hold pressure, it's a --

CHAIRMAN WALLIS: Yes. That's what I was getting at, too. It has two functions at least.

MR. SHERMAN: The last item I have circled on here are the items that say "pre-existing containment leakage," small opening/large opening. There are probabilities on the sheet here that show probabilities of E-3 for a small failure, larger for a big failure.

Those probabilities probably need to be adjusted because the leak rate test frequency is now different. Those are based on testing a lot more frequently. And then we don't think that they adequately consider the unexpected.

CHAIRMAN WALLIS: Are there parts of the environment through containment, which could be left open as a result of human action? I mean, are there valves or access ports or things that --

MR. SHERMAN: There are.

CHAIRMAN WALLIS: -- can be left open inadvertently by people?

MR. SHERMAN: Yes, there are, although my belief is that this fault tree accounts for that. There are other paths.

CHAIRMAN WALLIS: Well, people actions are rather hard to account for.

MR. SHERMAN: Whether it accounts for it in the human factors --

CHAIRMAN WALLIS: It's actually in the fault tree.

MR. SHERMAN: Yes. But whether it's adjusted to the human factors, the latest human factors that you have looked at, I can't answer. Looking at the fault tree relating directly to core cooling, that is the low-pressure core spray system. And on this fault tree, I would like to look at the right-hand side of it.

This is the portion that says low-pressure core spray loops fail to deliver flow. If you can read it well enough, you'll see that they expand into additional pages.

And I haven't given you those pages on the slides, but when you get down to the bottom, the element of interest is an element that is low-pressure core spray pump fails to run during emission time. That's what we're speaking about.

The probability in the fault tree is almost E-3, 8 times E-4. And we don't think that that probability takes into account everything that it should.

As a matter of fact, when we reviewed the IPE, where we've taken these from, we found this statement, "The low-pressure core spray pump unavailability due to insufficient NPSH caused by elevated suppression pool temperature is considered in the applicable event tree but is not included in the fault tree model."

CHAIRMAN WALLIS: Isn't there a problem with all of these PRAs that these boxes tend to be go/no go things and the pump fails to deliver flow? Well, the pump is probably delivering some flow under all conditions, but it doesn't deliver enough. So there's some sort of an it works or it doesn't work probability.

In reality, there is a whole continuum of ways in which it is working, which isn't in the PRA.

MR. SHERMAN: Exactly so.

MEMBER SHACK: And then it's through success criteria.

CHAIRMAN WALLIS: But there's just your success criteria, right? But it may well be that they are very conservative and that if the pump is delivering half as much flow, it still works perfectly well. But that's being erased because you now say it has failed.

MEMBER SHACK: I think your point is that there are assumptions. Even in PRA space, there are assumptions that are made.

CHAIRMAN WALLIS: Very much so. You're a believer, I see.

MR. SHERMAN: Summarizing what we have said, this is what we think is lacking. And this is a cut at a way to look at what we are saying. We think that there is a logic item that is pump fails due to inadequate NPSH that hasn't been included in the fault tree by the statement on the previous slide.

Among other things, it could include, number one, the probability that NPSH-r is not sufficient, that you don't know the right one from the vendor because the pump is old, the probability that the debris head loss is more than you expect it is going to be, the probability that the NPSH margin is insufficient, the probability that the containment is going to hold pressure. And you've got an event tree that shows that, but it's probably non-trivial to figure out how you fold that back into this place in the PRA space. I'm not saying this is easy to do.

Then the two things that David spoke about, probability that insufficient pressure is developed or the temperature is higher than you expected it to be --

CHAIRMAN WALLIS: I'm not a PRA expert, but it seems to me all of this flow forward stuff doesn't indicate the fact that something which happens downstream could affect something upstream. I don't know how they do that. There must be --

MR. SHERMAN: Well, neither do I.

CHAIRMAN WALLIS: -- feedback type loops in PRAs. And all of this is flowing forward. And this fails, and that fails and so on. There is no way in which something downstream can go back and loop and affect something by some --

MR. SHERMAN: Well, actually, we think that there is some looping here, but --

CHAIRMAN WALLIS: I don't know, but --

MR. SHERMAN: But we are not PRA --

CHAIRMAN WALLIS: I'm just thinking about it. Everything is so interdependent here.

MR. SHERMAN: Exactly so. And the last item that I have in the box is operator fails to retain. These are the uncertainties that we discussed that I --

CHAIRMAN WALLIS: You're redesigning the PRA.

MR. SHERMAN: Well, I'm only identifying what I think is not taken into account and that when you do take it into account, I think you conclude that you should retain the over-pressure as a conservatism, rather than give it away.

I've been going a long time. If you'd like me to terminate here, I can because the next items talk about specific flaws in the reg guide as given. If you want to give me another ten minutes, I can run through this. It depends on how your timing is.

VICE CHAIRMAN RANSOM: I think there is some time later in the day for feedback.

MR. SHERMAN: That would be fine.

VICE CHAIRMAN RANSOM: Maybe that would be the appropriate place to do that.

MR. SHERMAN: That would be fine.

CHAIRMAN WALLIS: Maybe we could get a debate going between you and the staff.

MR. SHERMAN: That would be good. We would like that.

VICE CHAIRMAN RANSOM: I think if that is okay, I will call for a break for 15 minutes.

MR. SHERMAN: From the State of Vermont's perspective, we would like to thank you very much for the opportunity to come and present our concerns.

MEMBER SIEBER: Thank you for coming here.

VICE CHAIRMAN RANSOM: Be back at 10 'til.

(Whereupon, the foregoing matter went off the record at 10:33 a.m. and went back on the record at 10:55 a.m.)

VICE CHAIR RANSOM: Can we proceed?

MR. LOBEL: We talked about the NRC position.

VICE CHAIR RANSOM: The new position.

MR. LOBEL: The new position, the new/old position. In order to understand the position a little and where we are, it would be helpful to consider the evolution of the position and a little of the history. Let me say first because this has been brought up before that there is no regulation that prohibits credit and containment accident pressure for available NPSH. We're talking about staff guidance and not GDC or any other regulation.

MEMBER SIEBER: What's the status of the old safety guides? Are they like regulatory guides like 1.1 for instance?

MR. LOBEL: Do you mean Safety Guide 1?

MEMBER SIEBER: Yeah.

MR. LOBEL: Safety Guide 1 is also called

Regulatory Guide 1 and that's part of this package to revise.

MEMBER SIEBER: Yeah, I read it. It's a one page deal.

MR. LOBEL: Yeah.

MEMBER SIEBER: But all the safety guides are gone now. Right?

MR. LOBEL: I don't know. I don't know about the others. Okay. We issued Regulatory Guide 1.1 or Safety Guide 1 in November 1970 and it dealt exclusively with calculating available NPSH.

CHAIRMAN WALLIS: So it's only regulatory guide?

MR. LOBEL: Right.

CHAIRMAN WALLIS: There's no regulation. The regulations were silent.

MR. LOBEL: The regulations speak to -- I think it's GDC 35 speaks to abundant ECCS flow and GDC 38 speaks to adequate containment cooling but not specifically NPSH. I've stated the position in the Reg Guide that you should assume the maximum expected temperature of the pump fluids and no increase in containment pressure from that present prior to the postulated loss of coolant accident. The NRC allowed credit for containment accident pressure for some reactors licensed before the issuance of the Reg Guide but reactors licensed after issuance of the Reg Guide generally complied with the guidance.

On December 3, 1985, the NRC issued Generic Letter 85-22 which discussed the findings of USI A-43 on containment emergency sump performance. The issue concerned the blockage of emergency core cooling systems, sump screens and PWRs and to a lesser extent potential for blockage in BWRs section strainers. The generic letter discussed the findings which included the fact that the blockage of the sump screens by LOCA-generated debris required a plant-specific resolution.

Remember before this, it was the 50 percent assumption for all plants, and a revised screen blockage model should be applied to the emergency sump screens. But the NRC regulatory analysis didn't support a back-fit of this guidance. So the guidance was if, Mr. Licensee, you change out your insulation and containment you should use this new guidance, but it was never a requirement. As part of the resolution, Reg Guide 1.82 was revised to Revision 1 to consider blockage and effects in a more physical way. I'm getting confused here with the slides.

Standard Review Plan Section 6.22 was also revised to include the following guidance that the NPSH analyses would be acceptable if it was done in accordance with the guidelines of NUREG 0897 which contain the technical findings of the USI and if it was done in accordance with Reg Guide 1.1. So even after the first examination of the effects of LOCA-generated debris on available NPSH and the proposal of uniform coverage, the guidance for NPSH was still Reg Guide 1.1.

Then in July of 1992, there was the Barsebäck, a Swedish boiling water reactor experienced spurious opening of a pilot operator relief valve at 435 PSIG and that resulted in dislodging some mineral wool insulation which blocked some emergency suction strainers. This led after several blockage events in this country and an extensive research and development to the NRC issuing Bulletin 96.03. All BWRs complied with the recommendations of 96.03 by installing larger, better designed ECCS suction strainers.

The design of these strainers took into account plant-specific debris loading of several types of materials and in general these loadings were predicted to be much higher than anticipated prior to the research which followed the Barsebäck event. This resulted in an increase in the predicted flow resistance across even these larger strainers which resulted in a decrease in calculated available NPSH. In some of these cases, this led to the necessity for containment accident pressure.

VICE CHAIR RANSOM: That was to meet the NPSH requirements?

MR. LOBEL: Right.

VICE CHAIR RANSOM: Where is the NPSH requirement more or less legislated that you must meet it?

MR. LOBEL: Well, like I was saying, there is nothing in the regulations. There are these reg guides that we're talking about. Other than that, it's just good engineering practice that centrifugal pumps need adequate available NPSH. They would just be part of the design basis of the plant when you pick a pump that that pump has to have a adequate NPSH.

VICE CHAIR RANSOM: So the hurdle is a reg guide and good engineering practice that you must --

MR. LOBEL: There are industry standards that deal with NPSH and calculating NPSH that I'll talk about a little later, but the NRC hasn't endorsed those in general. There is an industry standard on doing reactor-transient analysis which the NRC hasn't endorsed that tells you how to do containment analyses for different types of vents. But it doesn't talk about NPSH, doing containment analysis for NPSH. So really all there is is the closest thing in regulatory space are the reg guides.

MEMBER SIEBER: Well, and they aren't regulations.

MR. LOBEL: And they aren't regulations. Right.

MEMBER SIEBER: The regulations that one relies on are the general design criteria which says you have to cool the core and you have to cool containment to keep it from failure.

MR. LOBEL: Right.

MEMBER SIEBER: Everything beyond that comes from codes and standards and they get incorporated in the technical specifications and also LCOs and surveillances. So that's really where the stuff comes from.

VICE CHAIR RANSOM: What I"m hearing, normal pump operation like in a rocket or in an irrigation pump or something like that, of course, it's pump damage that you worry about from cavitation point of view. But here apparently, it's not so much damage as inadequate coolant flow.

MR. LOBEL: Well, I'd say both. You can maybe damage the pump to a certain point where you're not interfering with its safety function but it's really both. You don't want to damage at the pump and you obviously have to deliver the flow that you're assuming in your safety analysis.

VICE CHAIR RANSOM: My experience with cavitation is it's a fatigue-damage phenomena having to do with collapse on the surface and a fairly large number of cycles before you really begin to erode the material -

MR. LOBEL: That's one of these that --

VICE CHAIR RANSOM: -- as opposed to gross damage with a - going through the pump.

MR. LOBEL: Right, that's one of the effects, but you can also damage bearings and seals and other things if you have enough vapor that you start to get radial forces or axial forces that you haven't considered in designing the pump.

MEMBER SIEBER: And that's the area of concern. You're not worried about impingement pitting for a pump that's only going to run for 30 or 60 days. It's not long enough for you to change the flow characteristics of the pump. But constant vibration, high vibration, can destroy seals, destroy bearings and that's a problem.

MR. LOBEL: And when people have taken some credit for cavitation and licensees have, I'm going to get into this later, but it's usually that they've run a test with that pump or a similar design pump. They've run it in cavitation at the expected conditions and then they disassemble the pump and they look at shafts and bearings and impeller surfaces and things and they see that there's no damage for the length of time that they've run that pump.

In some cases, pump vendors make statements. Licensees will submit statements made by the pump vendor that says that we'll endorse that the pump can operate under these conditions for this length of time.

MEMBER SIEBER: And those are generally based on tests that the manufacturers run.

MR. LOBEL: Right, which may not be on that particular pump but on a similar pump.

VICE CHAIR RANSOM: What we've heard recently I think is that the likelihood of damage was much greater from debris, calcium silica and some of the other things that plugged some of the passages and erode the bearings. Those are not addressed, I guess, by this. Right?

MR. LOBEL: No, like I've said, I'm just talking about NPSH and I know the staff is working on downstream effects it's called but I'm not the person to discuss that. So I guess the point of all this with the Barsebäck event was that the Reg Guide was revised again to include the BWR guidance in May 1996.

As a related issue in '96 and '97 as a result of the NRC inspections and licensee event reports, the NRC became aware that available NPSH for ECCS and containment heat removal pumps may not have been adequate in all cases. This applied to both PWRs and BWRs. In order to understand the extent of the problem, the NRC issued Generic Letter 97.04 which requested licensees to provide current information regarding their NPSH analyses for the ECCS and containment heat removal pumps.

Again, there have been statements about not following the guidance in the Generic Letter 97.04. The Generic Letter didn't contain any requirements or request any actions other than a response to questions on NPSH calculations which included credit for containment accident pressure.

There were no review criteria in Generic Letter 97.04 itself. In some cases in response to 97.04, licensees had to revise their NPSH analyses and in some of these cases, licensees proposed credit for containment accident pressure. This was necessitated by things like finding that they had incorrectly considered flow losses and the BWRs, like I said, when they put in the larger suction strainers when they accounted for more debris they found some of them that they needed credit for containment over-pressure.

CHAIRMAN WALLIS: And this GED was satisfied by granting credit.

MR. LOBEL: Yes.

CHAIRMAN WALLIS: Was some criterion, the criteria, that you indicated at the beginning were used in deciding whether to --

MR. LOBEL: What we did was we went through the letters that were submitted from the licensees and reviewed them. As we did the reviews, we came up with positions on what was acceptable and not acceptable. We didn't publish those positions any place and they were only included in individual SERs as they applied to that plant review.

So leading into the next view graph, since the criteria weren't published before, we felt that in order to make them available they should be available to stakeholders and we included them in Reg Guide 1.82 Revision 3. The reason for doing that was that now

Reg Guide 1.82 Revision 3 contains all the regulatory positions in one reg guide related to all pump suction issues, vortexing, air entrainment, debris, blockage as well as NPSH.

So a stakeholder who wants to look at what the NRC position is on any issue that deals with pump suction can go to this one reg guide and find whatever guidance there is. It may not be all that complete in some cases. But the regulatory guidance we have would be in one place.

To bring up your predecessors again, we briefed the ACRS twice on NPSH credit for accident pressure. The last briefing was in December 1997 and particularly concerned the effect of the staff's position on beyond-design basis accidents and we, the Commission, received a letter from, to Chairman Shirley Ann Jackson, which concurred in it the NRC staff position but urged that all accident sequences should be examined as I quoted before. You'll see we've tried to include this in the reassessment that we're going to talk about today.

The reg guide allows credit for containment accident pressure and determining available NPSH but Reg Guide 1.1 and Standard Review Plan Section 6.22 do not. So that's the inconsistency that we're going to fix now. That's why all of these documents were included together.

Reg Guide 1.82 Revision 3 states that "Containment accident pressure should only be credited when the design cannot be practicably altered." It goes on to state that "No additional containment pressure should be included in the determination of available NPSH then is necessary to preclude pump cavitation." We propose to change these positions to the position I stated earlier which emphasizes safety and is more consistent with the staff reviews.

Essentially, we decided internally that there was really no practicable alternative that replacing RHR in core spray pumps in these older plants, and you'll see later I'll talk about the plants that this is applicable to, really wasn't a very practicable alternative and that we've always granted the pressure that was asked for when calculated with a conservative assumption. So essentially, we ended up with the position that we're at now and hadn't followed the positions of the regulatory guide.

VICE CHAIR RANSOM: What is the alternative? If you don't accept this, do you shut the plant down?

MR. LOBEL: If you don't accept it, usually the argument is about, the discussion is about, assumptions in the analysis. If there were some reason why we couldn't accept it, then the plant wouldn't be able to do whatever it was asking to do, the power upgrade for instance or operate with the larger --

VICE CHAIR RANSOM: Like the older plants, it couldn't satisfy it even under the current licensing basis. You didn't change the safety at all. You would simply allow them to continue to operate I guess.

MR. LOBEL: They could power down and maybe that would help with the flow they needed for the pumps.

VICE CHAIR RANSOM: But you don't require it.

MR. LOVEJOY: Or changing out -- Well, we don't require it. If there was something wrong with the analysis, something we wouldn't accept, then we'd look for alternatives. If there wasn't any good alternative, then the plant wouldn't be able to do whatever it was asking to do. We haven't gotten to that situation with anybody.

The analyses for the BWRs are fairly

standardized and very conservative like -- I'll talk about before. If there were a problem with blockage of the suction strainers in the BWRs, even in the PWRs I suppose too, they could change out insulation and go to some insulation that would be -- Get rid of the Calsil or whatever and go to an insulation that would give them better, more favorable, characteristics. It hasn't been a case of go or no-go yet. It's been more a case of discussing assumptions and modeling.

MEMBER SIEBER: I think one way to look at it is that for every plant regardless of the type or design as you increase power you will reach some limit someplace.

MR. LOBEL: Right.

MEMBER SIEBER: And this cooling of containment and core cooling could involve one of those limits.

MR. LOBEL: Yeah. In this case, the flow rates of the pumps we're talking about aren't increasing. The analyses are showing that they're still acceptable at the higher power conditions or with the increased blockage or whatever.

CHAIRMAN WALLIS: So on this slide, you're going to get rid of these two statements.

MR. LOBEL: Yes.

CHAIRMAN WALLIS: Because precluding pumps -- is a bit awkward. Since we've heard that NPSH-r corresponds to operating with the pump with quite a bit of cavitation. So you have to have a different definition of NPSH in order to preclude pump cavitation all together.

MR. LOBEL: I've tried to use the two terms that are technically used "available NPSH" and --

CHAIRMAN WALLIS: But they're not the same. I don't think we have -- I don't think pump manufacturers give you a number for the onset of the very, very first cavitation.

MR. LOBEL: Oh no.

CHAIRMAN WALLIS: That would be precluding cavitation, wouldn't it?

MR. LOBEL: That would be precluding cavitation. That's right.

CHAIRMAN WALLIS: So it's not a very good definition.

MR. LOBEL: And it's not a very good -- That's right. It's not a very good technical statement. The onset of cavitation is at some much higher -- That was the factor of two or twenty that was quoted before.

CHAIRMAN WALLIS: There are certain points in the pump which are particularly susceptible to cavitation and you might get a little bubble there pretty early on.

MR. LOBEL: Right. The standard pretty much has been a three percent drop in head. Some people have proposed a five percent drop or head or even more, but the required NPSH typically is the three percent. The reasons for that are that three percent when you're doing the test is easy to notice. You can see a three percent drop in head when you're doing these tests.

The other reason is that to throw in another term for low suction energy pump -- That's a term that's used by the hydraulic institute and in other papers for characterizing the tendency of pumps to cavitate and to cause damage to the pump. For low suction energy pumps, the three percent doesn't result in any damage to the pump. The pump can operate for a very long time with a three percent head drop for those types of pumps. I won't quote the staff position again. It hasn't changed between earlier and --

MEMBER KRESS: What does the guidance go on to say, going back to your slide, what is meant by sufficient pressure? Is there still guidance on keeping a certain margin between it?

MR. LOBEL: Yeah, that's a little complicated. It's kind of a complicated subject but what the staff has always accepted is that the available NPSH could be equal to the require NPSH. That would be acceptable. When the containment --

MEMBER KRESS: Without any additional margin.

MR. LOBEL: Without any additional margin.

MEMBER KRESS: I thought that margin is in there because it's calculated conservatively.

MR. LOBEL: Yeah. Without any additional margin in that particular aspect, but as I'm going to get to in a few minutes, there's a lot of margin in the containment analysis and the other analyses.

MEMBER KRESS: So it's just not in the calculations.

MR. LOBEL: It's not in the required equally the available NPSH. We're not putting margin in that. The reason is it really gets behind what we know what's been tested about these pumps. We know that at a margin ration of one, NPSH/NPSH-r at a margin ratio of one, the cavitation damage really isn't that bad that tests have been done, have shown that when you have a margin slightly above one, whatever slightly is and it varies with the pump design, you're more likely to have cavitation damage than at a ratio of one. Until you get to a point where you have so much available NPSH that you don't have a cavitation problem anymore.

So it's hard to define where, if you're not going to pick that point, you're going to be, where you should be, and then also this is a design-basis calculation and there's a lot of conservatism. So you don't really know truly where you are. You know you're bounding. I'm going to talk about the conservatism. You know you're bounding. You put enough conservatism in that you know you're bounding, but you don't know really truly where you are at any time.

MEMBER KRESS: That's troublesome how you know you're not right on that peak damage point.

MR. LOBEL: I'm going to talk about conservatism a little more.

VICE CHAIR RANSOM: That's an issue that, I think, needs to be clarified because according to some of the pump articles, the peak damage point is between zero and three percent drop in head as opposed to being beyond three percent which would imply that from a damage point of view operating at less than one for the NPSH-r would be okay from a damage point of view but maybe not from a core cooling supply point of view.

MR. LOBEL: That's true. You would have to know what the change in flow rate would be. But again, you have to go back to the fact that these analyses are done conservatively and like I was going to talk about a little later, the flow that you assume in the NPSH analyses is greater than the flow you assume in the ECCS analyses, in the LOCA analyses. So you have some conservatism in that as well as the conservatism and the temperatures and the pressures in everything else.

VICE CHAIR RANSOM: Where did that conservatism come from? You reduce arbitrarily the flow that the pump will produce?

MR. LOBEL: No, you increase the flow.

VICE CHAIR RANSOM: I thought you said that --

MR. LOBEL: When I do my LOCA analysis, peak clad temperature calculations, I'm assuming a certain pump flow or a certain pump curve. When I do the NPSH calculations, I assume a flow that's higher than that flow and the reason I do that is because that increases the required NPSH. The required NPSH goes up as I increase the pump flow. So by assuming a higher flow for the NPSH calculation, I'm reducing the margin between available and required.

MEMBER SIEBER: Since we're talking about margin, you indicated that the calculations for the containment response gave margin.

MR. LOBEL: Right.

MEMBER SIEBER: In other words to me that means that the pressure that actually will be achieved is higher than the calculation would predict.

MR. LOBEL: Right.

MEMBER SIEBER: Is this the same calculation that one would use for containment leakage to look at Part 100 or is it a different calculation or do you play with the margins somehow? Because if it's conservative for the pump, it's nonconservative for leakage.

MR. LOBEL: There are two calculations that are done. There's one that's done for NPSH and another one is done for peak containment pressure when you're comparing with the design pressure of the containment. So there are two separate calculations with separate assumptions and in a lot of cases with just the opposite assumptions.

In one case for example, you're trying to maximize the amount of air in containment because that gives you a high pressure. In the other case, you minimize the amount of air in containment because that gives you a minimum pressure. So I pick my initial conditions for the containment calculation in a way that does that.

MEMBER SIEBER: Okay.

MR. LOBEL: So there are actually two separate calculations.

MEMBER SIEBER: Actually, two different calculations because they're incompatible if you were to use the same calculation.

MR. LOBEL: Now for PWRs, you already have two calculations. For LOCA analysis, you have one that's done for the peak containment pressure.

MEMBER SIEBER: Right.

MR. LOBEL: And then for the LOCA calculations for the peak clad temperature calculations, you minimize the containment pressure and there's a Standard Review Plan Section. I'm going to talk about that a little later too. So PWRs already do that. They do a peak pressure calculation and a minimum pressure calculation with different assumptions.

MEMBER SIEBER: But neither one of those has a specific purpose to see that you had actually ruptured containment. To me that's not -

MR. LOBEL: The peak pressure does.

MEMBER SIEBER: Yeah, but you have a margin of like three.

MR. LOBEL: You compare with the design pressure.

MEMBER SIEBER: Yeah.

MR. LOBEL: You have to stay below the containment design pressure.

MEMBER SIEBER: But the breaking pressure is three times the size of that. What's important of it is leakage. If you are running pretty close to Part 100 limitations, you have to really pay attention to the leakage.

MR. LOBEL: Right.

MEMBER SIEBER: And so these assumptions become important.

MR. LOBEL: And that could be yet another calculation to calculate the dose.

MEMBER SIEBER: Yeah.

MR. LOBEL: That's another yet calculation that licensees do and they do that calculation to be conservative for dose release.

MEMBER SIEBER: Yeah, I think it's important to keep in mind that these aren't the same calculations.

MR. LOBEL: Right.

MEMBER SIEBER: And they aren't done the same way and they have a built-in bias to provide conservatism for the purpose for which they're used.

MR. LOBEL: Yeah, and I have a lot of slides on conservatism because I wanted to make that point to the Committee.

MEMBER SIEBER: You show us your best one.

VICE CHAIR RANSOM: Where is that margin that you spoke about between that assumed for core cooling as opposed to the NPSH analysis? Where is that specified? I don't believe it's in the reg guide.

MR. LOBEL: It's not. It's just in the way the calculations are designed.

VICE CHAIR RANSOM: Is that up to the vendor or the utility?

MR. LOBEL: Everybody pretty much does the same thing and the NRC's accepted it. I've never seen -

VICE CHAIR RANSOM: Is it like five percent? Ten percent?

MR. LOBEL: No, it's -- I'm not sure.

VICE CHAIR RANSOM: I'm wondering how you qualified this margin.

MR. LOBEL: I was referring to saying that the available NPSH is equal to the required --

CHAIRMAN WALLIS: No, the flow rates he's talking about.

VICE CHAIR RANSOM: No, the flow rates.

MR. LOBEL: The flow rates?

VICE CHAIR RANSOM: You said the flow rates were different that were used for, say, the core cooling analysis as opposed to the NPSH analysis.

MR. LOBEL: Right. Where is that qualified?

VICE CHAIR RANSOM: I'm wondering how is that set.

MR. LOBEL: It isn't specified anywhere. There's a lot of conservatisms that licensees has just included in this analysis.

VICE CHAIR RANSOM: So it's up to the licensee to set that.

MR. LOBEL: Yeah.

CHAIRMAN WALLIS: It would really help if they would all do realistic calculations with uncertainties. All this argument about conservatism here and conservatism there.

MR. LOBEL: Maybe I'm giving you the wrong impression I think. What they do is they set the pump flow in terms of failure that are hypothesized in a BWR in the short term and by "short term," I mean for the first ten minutes before you take operator action. The single failure that's taken is a failure of what's called LPSI loop select logic and what that does is it allows the LPSI pump flow to essentially go right out into the containment and so the pump is run-out conditions for that first ten minutes. So it isn't so much that somebody's defining the margin. It's set by the single failure assumption.

They found the worst single failure is failure of LPSI loop selection logic. That sets it for the first ten minutes. Then after that time, after the operator can take some action, the operator would obviously throttle the pump so it's not at run-out anymore but it would still be at some high flow rate. But it's defined more by the single failures and the conservative flow like the design pump flow or rated flow or some value like that. It's not arbitrary.

CHAIRMAN WALLIS: Now on this subject of NPSH, you're assuming a margin of one and we heard this morning, earlier this morning, from Bill Sherman that ANSI recommends a margin of 1.5. So that would mean that this referenced plan which is spoken of here with the 32 foot NPSH CHAR if you follow the standard would require 48 foot NPSH. It just seems to me a huge difference. You guys are not requiring any of that at all.

MR. LOBEL: Let me discuss that standard and the 1.5. As I read that standard, I wouldn't apply it to these pumps. I think what the standard had in mind when it was talking about nuclear pumps was the recirculation pumps and the feed pumps and pumps like that that are going to be in continuous operation where cavitation is a concern because these pumps are going to be operating for years at a time, not for the situation where you have an emergency and you want the pump to operate and you're not going to get that kind of margin. It's just not in the designs and it's probably not necessary.

The 1.5 is a large value anyway. Other sources recommend 1.3 for continuous operation and some experts I've seen say that 1.0 is okay. It depends to a large extent on this thing I was talking before the suction energy level of the pump. The margin standard talks about three suction energy levels, low, high and very high.

ECCS pumps tend to be slightly above low in the low/high range, just into the high range. There's a formula for calculating the suction energy level. It's kind of a semi-empirical value. It isn't that well defined. It's not a thermodynamic calculation that you do. It's a function of the speed of the pump, the diameter at the eye of the impeller, the specific weight of the fluid and things like that that would affect the suction.

CHAIRMAN WALLIS: It has to do with the velocity head of the fluid coming into the pump or something.

MR. LOBEL: Right.

CHAIRMAN WALLIS: If you have a restriction there, it's bigger.

MR. LOBEL: The tendency of the fluid coming into the pump, the flash.

CHAIRMAN WALLIS: Right.

MR. LOBEL: So low suction energy level pumps tend to not have a problem at all and they can run in cavitation and not have a problem. The high suction energy level pumps have more of an issue with cavitation. The very high suction energy level pumps, you could have severe damage from cavitation and it's related -- Well, I won't go on with it.

CHAIRMAN WALLIS: So you have good reason for not accepting this ANSI standard and the rationale is written down somewhere, is it?

MR. LOBEL: No, it's not written down.

CHAIRMAN WALLIS: So some member of the public might have reasonable expectation that you would abate a standard and they wouldn't know where to look to see why you were not doing so.

MR. LOBEL: That's a fair comment. We can put that as a --

CHAIRMAN WALLIS: I think you ought to rebut this somehow if you're not going to use some standard. There's a good reason for why. That needs to be recorded somewhere.

MR. LOBEL: I'm not sure. This is a 1998 standard.

CHAIRMAN WALLIS: It's not so long. We're using standards older than that.

MR. LOBEL: I don't believe it's even endorsed by the hydraulic institute or ANSI anymore because it's over five years old and I'm not sure they're working on it.

CHAIRMAN WALLIS: We have another ANSI standard, don't we, about zone of influence and stuff too, that maybe we should also treat the same way?

MR. LOBEL: I won't get into that.

VICE CHAIR RANSOM: Misunderstands something of that same statement that says "or three feet" which was in error.

MR. LOBEL: I honestly don't remember the three -- It's there if they say it's there.

VICE CHAIR RANSOM: Right. I think I read that and three feet would be almost no margin.

MR. LOBEL: Yeah.

VICE CHAIR RANSOM: So I'm wondering why compared to the one and a half certainly.

MR. LOBEL: I don't know. I can't answer that.

MEMBER SHACK: Let me just come back to in the reg guide itself I can't find and maybe you can point it to me where the beyond the design basis accident consideration comes in. Is that something only the staff is going to consider? You're not really expecting the licensee to address it.

MR. LOBEL: We've been talking about that. That's something that's evolving and maybe Artie wants to talk about that more, but we've been talking about that since this draft was sent to you.

MR. STUTZKE: It's my opinion although it hasn't gone outside of our branch or division or whatever, but my personal opinion at this time in the future the licensees that request credit for containment of a pressure should do a complete -- analysis.

MEMBER SHACK: We need a Rev 5.

MR. STUTZKE: Of this.

MR. LOBEL: That would be just a comment for this one.

CHAIRMAN WALLIS: I don't understand this statement at all on 20. Are you going ahead now? Credit is allowed when? First of all, say that you need it. If you don't need it, why do you have to analyze and conservatively demonstrate it that sufficient pressure is available for design basis accidents?

MR. LOBEL: If you don't need it, there's no such analysis.

MEMBER SIEBER: You wouldn't ask it if you didn't need it.

MR. LOBEL: Right.

CHAIRMAN WALLIS: So there's no screen that says first of all you have to need it.

MR. LOBEL: No.

MEMBER SHACK: There sort of is in 1.3.11.

That first paragraph is when you don't need it and then you use the simplified one.

CHAIRMAN WALLIS: Because this kind of implies that you have to always do this conservative analysis whether you need it or not.

MR. LOBEL: The way it's done is you assume a value of required NPSH for your pump and then you --

CHAIRMAN WALLIS: You calculate what you need. Right?

MR. LOBEL: You start with the required NPSH.

CHAIRMAN WALLIS: And then you see if you need to get any credit for containment pressures.

MR. LOBEL: Then you do a calculation of the available NPSH without credit for containment pressure.

CHAIRMAN WALLIS: Right.

MR. LOBEL: If the available is above the required, you're done. If the available is below required, then what's done is you take enough credit in containment pressure so that the available is equal to the required.

CHAIRMAN WALLIS: So sufficient pressure is available means that you meet the NPSH-r with a margin of one.

MR. LOBEL: Right.

CHAIRMAN WALLIS: That's what you mean by sufficient pressure is available.

MR. LOBEL: Yes.

CHAIRMAN WALLIS: That's going to be spelled out clearly then because sufficient pressure, somebody could argue that we could have a margin of 0.9 but we still have enough flow because the pump has been shown to work.

MR. LOBEL: You've made all these conservative assumptions when you did the containment amount analysis, when you've calculated the available.

CHAIRMAN WALLIS: I don't mean that. You could go to a pump curve and some tests and show that with a margin 0.9 I still get enough flow to cool the core. Is that acceptable?

MR. LOBEL: That's done.

CHAIRMAN WALLIS: That is done too.

MR. LOBEL: I was going to talk about that.

CHAIRMAN WALLIS: That is also done.

MR. LOBEL: Yes.

CHAIRMAN WALLIS: So there's nothing that says that you have to meet NPSH-r.

MR. LOBEL: That's desirable but in some cases, licensees have gone to their pump vendor or done tests and shown that they can operate in cavitation for a certain length of time when they're below the required and not cause any damage.

CHAIRMAN WALLIS: So really what one should say is analysis conservative to demonstrate that sufficient flow is available for design basis accidents. That's your real criterion is that you do all this stuff and then you say with a conservative estimate of all these pressures and stuff, do I have enough flow. Isn't that it?

MR. LOBEL: But the assumption is if you have sufficient available NPSH that you have enough flow.

CHAIRMAN WALLIS: But you were selling me that if you had a margin of 0.9 you could still make enough flow.

MR. LOBEL: Right.

CHAIRMAN WALLIS: So sufficient NPSH isn't really the criterion. It's having enough flow to cool the core that's your criterion, isn't it?

MR. LOBEL: Yes.

CHAIRMAN WALLIS: It seems to me that you really should say the sufficient flow is available.

MEMBER SIEBER: That you won't be on pump curve if you don't have enough NPSH. How much flow you get is part of the pump characteristic. But to get on the curve at all, you have to have sufficient NPSH to define where you are.

CHAIRMAN WALLIS: Well, for different pressures in the containment once you begin to get into this region, you get progressively less flow and as you decrease the pressure that's available and not credit it, you get less and less flow. There's a certain point where you don't have enough flow to cool the core, is that the cutoff point?

MR. LOBEL: No, hopefully you're always above that. If you're not above that, you have a problem.

CHAIRMAN WALLIS: Well, if you're over the need far enough you might not have enough flow.

MR. LOBEL: Sure.

CHAIRMAN WALLIS: But that's not what you work on. You work on NPSH-r. What's your criterion that you're applying? I thought --

MR. LOBEL: The criterion is that the available is equal to the required.

CHAIRMAN WALLIS: Which is NPSH-r?

MR. LOBEL: Which is NPSH-r. Right.

CHAIRMAN WALLIS: I thought we had a discussion that you could be down at 0.9 HPSH-r and still work.

MR. LOBEL: You can do that. There's a position in the reg guide that says you can do that if you've done testing to show that the pump will still --

CHAIRMAN WALLIS: Provide enough flow.

MR. LOBEL: -- provide enough flow. Right.

CHAIRMAN WALLIS: So flow is the ultimate criterion then.

MEMBER SIEBER: Yeah.

MR. LOBEL: Yeah.

CHAIRMAN WALLIS: Okay.

MR. LOBEL: Let me point out then that when PWRs do a LOCA analysis, their peak clad temperature analysis, they take credit for containment accident pressure in the same way that we're talking about for NPSH. It's a minimum pressure calculation. And the reason they do that is that when you're reflooding the core, the rate that you're reflooding the core depends on the containment pressure.

So Appendix K says minimize that pressure. It doesn't say don't take credit for pressure. It says minimize that pressure and there's a Standard Review Plan Section that has guidance on how to minimize that pressure. So NPSH isn't the only place in licensing space where credit is taken for containment accident pressure. It's not unique.

CHAIRMAN WALLIS: But when you're reflooding the large LOCA, isn't the pressure in the reactor cooling system about the same as containment?

MR. LOBEL: Yeah, and -

CHAIRMAN WALLIS: So you have a loop and then you're artificially saying that it's probably against 50 psi but it's only sucking at 1 psi.

MR. LOBEL: Right.

CHAIRMAN WALLIS: So it's -- artificial.

MR. LOVEJOY: That's the conservatism. And if you said I had 50 psi then you'd probably fill up right away.

VICE CHAIR RANSOM: So you're saying you take the minimum pressure for the pump suction or capability but the higher pressure for what it's pumping against. Is that right? The reflooding the vessel.

MR. LOBEL: Yeah, they're two separate calculations. When I'm doing the calculation for -- Well, it's pretty much the same. It would be different containment pressures. For the NPSH, I'm minimizing the pressure that I'm going to use to determine the allowable NPSH. When I'm doing the peak clad temperature calculation in a BWR, I'm not really sure what pressure they use for that analysis. It's not the minimum.

When you do the calculation in a PWR, the PWR calculation would use this minimum pressure. I believe that's right. Is that right? Yeah.

VICE CHAIR RANSOM: The PWR would use the minimum pressure.

MR. LOBEL: The PWR would use the minimum pressure for both cases, for minimum NPSH and it would use the minimum pressure for both the reflood and for the head the pump was pumping against into the core.

CHAIRMAN WALLIS: But the pressure in the core makes a big difference to the pool swell and all that kind of stuff.

MR. LOBEL: Right.

VICE CHAIR RANSOM: But that pressure was for a different purpose. That's to maximize the flow out of the vessel, I think. Right? Or the containment pressure?

MR. LOBEL: At that point, yeah.

VICE CHAIR RANSOM: You have the vapor

flow or -- flow.

MR. LOBEL: Yeah, you would get more flow out with lower pressure.

VICE CHAIR RANSOM: It has other --

CHAIRMAN WALLIS: This shows there are so many things that are interrelated and it would be really good to do a realistic calculation of the whole works and then see what's the probability of something going wrong. It's very hard. Something that's conservative here isn't conservative for that and so you get into this logical mix of stuff which is hard to justify.

MR. LOBEL: That's the box that we put ourselves into with design basis analyses. We try to make them conservative and like I'm going to say in a little while --

CHAIRMAN WALLIS: Now there's something called geolistically conservative.

MR. LOBEL: Whatever that is.

CHAIRMAN WALLIS: I think realistically conservative is close to what I was saying. You do more realistic calculations and then you look at how far away from it you could be rather than taking some absolutely extreme case.

MR. LOBEL: Should I continue?

CHAIRMAN WALLIS: Sure. I'm sorry, but you have all day and all evening too.

MEMBER CARUSO: You want to start the new section.

MR. LOBEL: I was thinking if we break for lunch now. I was going to get into the technical justification for over pressure which is a big discussion.

CHAIRMAN WALLIS: Maybe we need to have a break, do we? I'll leave it to the chairman.

VICE CHAIR RANSOM: Is this the methodology?

MR. LOBEL: Yes.

CHAIRMAN WALLIS: How long would it take to do that? Quite a while, wouldn't it?

MR. LOBEL: Quite a while.

VICE CHAIR RANSOM: Why don't we break for lunch and then --

MR. LOBEL: It's broken up into different subjects. I could do one subject and then we can break if you want. I could do containment integrity and then --

MEMBER SIEBER: Let's break now.

VICE CHAIR RANSOM: Want to break and be back at 1:00 p.m.

CHAIRMAN WALLIS: Can I ask you something though? When are you going to do all this? Are you just show us words or are you going to show some typical numbers for things so we can put this into some perspective?

MR. LOBEL: I have some numbers for some things but I didn't include -

CHAIRMAN WALLIS: You talk about things big or small and all that. I have no idea about how big the numbers really are. Maybe when you talk about conservatism and maybe there's a huge conservatism because the pressure is really 20 psi and you're forced to assume it's zero. Maybe there isn't. I don't know. So if you could give us some numbers that would help.

MR. LOBEL: I can give you some of those numbers.

CHAIRMAN WALLIS: Maybe that would come up in questioning.

MR. LOBEL: I can give you some of those numbers. They're not for one plant and they won't be consistent from one plant to another.

CHAIRMAN WALLIS: I don't know whether this only comes up in large break LOCA or does it come up in medium size or small break. That sort of thing would help me too because if it only comes up in large break LOCA, I can know what kind of scenario I'm thinking.

MR. LOBEL: Okay. It's typically large break, but again not always and what licensees do is they would do a spectrum of breaks. For instance, one licensee has a PWR, has an analysis in now, where the small and intermediate breaks actually give the worst NPSH conditions. So they did the right thing. They looked at whole spectrum of break sizes and break locations because again we're talking about different analyses and the break location that gives you the worst peak cladding temperature may not be the break location that gives you the hottest sump temperature for NPSH. So you have to look --

MEMBER SIEBER: A small break wouldn't do that.

MR. LOBEL: Right. There's a lot of things that change. They're two different analyses. Like I was saying before, the distribution of energy into the containment atmosphere from the break, you make one assumption for peak pressure and you make another assumption for NPSH calculations. Then you have more realistic codes that are in between.

Let me just say one more point and I'll

stopped. That's why it's hard in the reg guide to be too specific and too cookbookish about what should be done because it's really up to a licensee for his particular plant to do the calculation over a spectrum of breaks and locations and size of breaks and all that to find out what the limiting conditions are and where is a single failure and all those types of things.

VICE CHAIR RANSOM: All the more you think the reg guides should specify that if you're going to take credit for this then you should consider these things.

MR. LOBEL: It tried to do that and I'd be interested in people's comments. I really would like your comments and when it goes out for public comment to get people's comments on the level of detail and what it says. I'm hoping for comments from pump vendors and from the industry on some of the guidance too. If we're doing this now, if we're trying to put out guidance for people, I hope we can do it right and not have to have a revision 5.

CHAIRMAN WALLIS: So we're going to see it as a full committee in September. We're going to take this up and then you're going to put out the guidance and then maybe next year some time, June or something, we go through this again.

MR. LOBEL: Yeah.

MEMBER SIEBER: I think if we have any great concerns about what they're proposing even before public comments come in we ought to state our concerns.

MR. LOBEL: Right.

MEMBER SIEBER: Otherwise it will go there and then our concerns will get all mishmashed in with the public comments and they're more difficult for the staff to deal with in that context.

VICE CHAIR RANSOM: Okay. We start promptly at 1:00 p.m.

CHAIRMAN WALLIS: One. Thank you. Off the record.

(Whereupon, the foregoing matter went off the record at 11:54 a.m. and went back on the record at 1:03 p.m.)

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

1:04 p.m.

VICE CHAIR RANSOM: On the record.

MR. LOBEL: So far I have been discussing what we're proposing to do and now I'd like to go through our reassessment and I'll try to go a little fast. We looked at five factors that should be considered in credit in containment accident pressure, that there's a high confidence in the integrity of the containment, that conservative calculations are done, that the ECCS and containment spray pumps are of robust construction and made from cavitation, damage-resistant material, the fact that the emergency operating procedures aren't significantly altered by dependence on containment pressure and that the risk calculations show an insignificant increase in risk due to reliance on containment pressure.

MEMBER KRESS: High confidence in containment, does that relate to beyond design basis accident?

MR. LOBEL: No. That's for design basis. Yeah.

MEMBER DENNING: What's the reluctance to change the EOPs?

MR. LOBEL: There's not a reluctance.

It's just not necessary and I'll explain. There's no reluctance to change.

One of the rationale in Reg Guide 1.1 for not crediting containment accident pressure for NPSH calculations is the possibility of impaired containment integrity. All design basis analysis assumes containment integrity. This is acceptable since the containment is subject to tests that verify its integrity.

First, there's a structural test that's performed before licensing. Then there is 10 CFR 50.54 (O) Appendix J that requires periodic leakage rate testing of the containment structure and penetrations and 10 CFR 50.55(A) that requires periodic in-surface examination of inspections of the containment structure in accordance with the ASME code.

MEMBER KRESS: In our reincarnation of ACRS, we talked about this required leak testing of containment and the idea was how frequent should it be. And they extended the frequency to ten years I think.

MR. LOBEL: Fifteen.

MEMBER KRESS: Fifteen. It was five or something.

MR. LOBEL: It was three times in ten years originally. That Option B changed it to one time in ten years and now we are giving extensions to 15 years.

MEMBER KRESS: As I recall the arguments for that, for allowing such a thing, were all the risk arguments, that it didn't increase the risk very much if you did that. Now we're talking about design basis space and whether or not this leakage might be -- We may not know what it is and it may be too big to incorporate in a containment pressure. Have I that wrong?

MR. LOBEL: Let me try to state it. We had three times in ten years. We went to one time in ten years with Option B. Option B was called Risk Base. It partly based on risk arguments. A lot of it was based on experience. We went through the database of events that challenged the integrity of the containment and Option B changed the way things were done from the way Option A, the old Appendix J, did things.

In Option A, the old Appendix J, containment integrity looked at leakage through valves and penetrations as well as through the containment structure. What Option B did was to separate the two and now the ILRT essentially looks at the containment structure and the penetrations and isolation valves have a different frequency.

So you can't fail an ILRT, a global containment leakage test, because of a failure of a valve. You can fail the leakage through that valve but that's a different set of actions.

MEMBER KRESS: Those are the more likely.

MR. LOBEL: Those are the more likely things to happen and you test those more often. They're tested --

MEMBER KRESS: Perhaps.

MR. LOBEL: So you have to have two successful tests and then you're allowed to go to five years and you can stay on a five year interval until you fail a test. Once you fail a test, you go back to the every outage testing.

MEMBER KRESS: So they're more likely on accounting on a leak test of testing more frequently.

MR. LOBEL: Right. When we talk about extending the frequency for the ILRT, that's just for the containment structure, the liner and that type of thing. But the penetrations are on a much more frequent schedule and that hasn't been changed. There's some talk by the industry of changing that but that hasn't been changed.

MEMBER KRESS: This looks like a reason not to change it.

MR. LOBEL: Yeah.

CHAIRMAN WALLIS: You said something about design basis here. We're talking about beyond design basis as well, aren't we?

MR. LOBEL: We'll get to that a little later.

CHAIRMAN WALLIS: There's no risk if there's no design basis, is there? Isn't it that design basis acts as don't contribute to risk?

MR. LOBEL: The way things are laid out is the accidents that licensees looked at for this or the deterministic analyses are design basis accidents or I don't know what you would call close to design basis accidents, the Appendix R fire, the station blackout, those kinds of things that we don't call design basis but they're close to that. Those get looked at from a deterministic point of view.

Licensees use conservative calculations and they assume containment integrity pretty much for those. Then the part that Marty will talk about later, the risk part, gets into beyond design basis.

CHAIRMAN WALLIS: Some DBAs, beyond design basis accidents, the containment integrity is not particularly good.

MR. LOBEL: Right.

MEMBER KRESS: But you only get into those conditions if these things don't work. So you're asking why you need to make things work.

MR. LOBEL: Right. So for these calculations, the design basis, you're saying I'm making a set of assumptions, conservative assumptions hopefully, and I'm demonstrating that everything's going to work, that my safety limits are protected. Then I'm going to go past that and I'm going to say now I'm allowing things to fail. Penetrations can fail. Pumps can fail. And I'm in a new set of circumstances and I look at that from what's the likelihood of that and what's the consequence of that.

So it's different. We're looking at that in two different ways. Licensees have to satisfy their licensing basis which is the deterministic calculations. Did I answer your question?

CHAIRMAN WALLIS: Well, I think we're looking primarily at what you just mentioned, the licensing basis type calculations.

MR. LOBEL: Right.

CHAIRMAN WALLIS: But when you get into

risk, you're looking at a different space.

MEMBER DENNING: Can I -- I want to ask how Marty related to this. I realize we're not cutting into the PRA space at the moment but there's PRA insight into what the frequency of failure to isolate. I'm wondering what do the risk numbers now say as far as the potential under a design basis condition did you actually would have had failure to isolate.

MR. STUTZKE: I don't know if I can give you a direct answer. The way to look at it is the PRA lays out a series of accident sequences through an eventual structure. Some of those sequences are successful. Those generally are design basis accidents. Everything is okay, the ones that lead to core damage or beyond the design basis because of multiple failures and things like that.

MEMBER DENNING: Yes, but there is a failure to isolate which one uses later on severe accident space.

MR. STUTZKE: Right.

MEMBER DENNING: But the data you gain relates to frequency of failing integrated leak -- That's where these more focused tests are now and what is that now telling us that that failure rate is?

MR. STUTZKE: I've have that back in my presentation a bit later.

MEMBER DENNING: You have it some place in there.

MR. STUTZKE: Yes, I have an estimate of the probability that containment integrity has lost therefore causing the loss of over-pressure. I have that estimate.

MR. LOBEL: As I showed earlier, a majority of the containments, crediting containment accident pressure are BWR mark ones. The containment integrity for a mark one pressure suppression containment is continuously monitored during normal operations since the containment is inert. All mark ones are inerted except for 24 hours after start-up and 24 hours prior to shutdown. That's required by regulation in tech specs.

So any significant increase in the amount of nitrogen that has to be added to the containment might be assigned a degradation in the containment integrity and would be observed by the operators. The operators would then take the action that was appropriate in accordance with the plant's abnormal operating procedures.

Another sign of loss of integrity would be the presence of oxygen gas in containment. The tech specs require oxygen monitors as part of 10 CFR 50.44 in the tech specs and the monitors would provide a continuous insurance that there's no oxygen. So again, if oxygen were detected, the operators would take the appropriate action according to their abnormal operating procedures.

MEMBER SIEBER: But the containment operates at basically atmospheric pressure.

MR. LOBEL: Right.

MEMBER SIEBER: And so if it's atmospheric pressure, it's an equilibrium with the outside. So even if you didn't have integrity, you may not leak.

MEMBER KRESS: You'll get leakage. You'll get little fluctuations.

MEMBER SIEBER: It would be very subtle.

MEMBER KRESS: Yeah, it's subtle but you'll get it. Then there's day and night differences.

MR. LOBEL: It's not exactly the same and some containments are operated slightly below atmospheric.

CHAIRMAN WALLIS: Atmospheric pressure fluctuates by ten percent anyway.

MR. LOBEL: Yeah.

MEMBER KRESS: That's what I was talking about.

CHAIRMAN WALLIS: It comes in and out.

MR. LOBEL: The second largest group of containments crediting accident pressure were the PWR subatmosphere containments and the same kind of logic holds that they have to maintain a vacuum. If they can't maintain the vacuum, they're required by tech specs to shut down within an hour.

Another check on containment integrity is the walkdown that operators do to check valve alignments and other configuration issues prior to startup and during startup from an outage.

An assertion has also been made that crediting containment accident pressure is a new containment safety function and the staff disagrees that containment integrity is required by regulations and technical specifications. Credit for containment accident pressure doesn't impose a new requirement. No more credit is taken for accident pressure than is conservatively calculated to be there and no new equipment is added or removed.

CHAIRMAN WALLIS: The presentation from Bill Sherman was that there were three lines of defense and if you have a LOCA, you've lost one of them. Then if you lose the containment, you've already lost your pumps and so you've lost two of your lines of defense by losing one because you've -- Isn't that the nice little argument he had?

MR. LOBEL: Yes, the defense.

CHAIRMAN WALLIS: The fuel would fail as a result of the containment failing. You don't buy that argument at all.

MR. LOBEL: I'm not talking about the defense.

CHAIRMAN WALLIS: Well, it's sort of related to that because he was saying by making the containment supply this pressure to make the pumps work to cool. He's fulfilling a new safety function that wasn't originally intended for.

MR. LOBEL: But the pressure is there. The containment is holding in the pressure and limiting leakage. It's nothing new.

CHAIRMAN WALLIS: But now it's being asked to supply a minimum HPSH pressure as well.

MR. LOBEL: Right.

VICE CHAIR RANSOM: How is that different than the requirement to contain the fission products and why not --

CHAIRMAN WALLIS: There's aren't any

fission products yet because the fuel is still intact. If you lose the containment first, then you might lose the fuel later.

VICE CHAIR RANSOM: But the idea was it's a pressure containment. Right? So it would be pressurized rather than allowing whatever is leaking to -- outside.

CHAIRMAN WALLIS: I know.

MR. LOBEL: Well, Mark is going to talk about the defense in depth part of this later.

CHAIRMAN WALLIS: Okay.

MEMBER DENNING: What is the meaning of the third bullet about nothing is done operationally to enhance or decrease the pressure? Isn't there an intent after the event to try to reduce the pressure but not too far?

MR. LOBEL: My point was just whatever is done is already done now. Part of the emergency operating procedures is to reduce pressure. So the operators are all ready. Their procedures right now even if they're not taking credit for containment pressure are to reduce containment pressure.

MEMBER DENNING: But within bounds.

MR. LOBEL: Yeah, I was going to talk about that a little later, but the EOPs for BWRs state that the operator isn't supposed to let the pressure get below a certain valve. Right now, the EPGs, the emergency procedure guidelines, say zero PSIG. It used to be 2 PSIG. Now it's zero PSIG. So that's what the operator is told now to protect.

CHAIRMAN WALLIS: It's not supposed to get below atmospheric?

MR. LOBEL: Yeah, for structural.

CHAIRMAN WALLIS: Then you can't get an credit for pressure if there isn't any.

MR. LOBEL: Right. So what would happen in a place that's taking credit for pressure is the number would change to a number consistent with their analysis. So that the operator would be told instead of letting it go below a zero PSIG don't let it go below 6 PSIG.

CHAIRMAN WALLIS: So it conflicts with your third bullet then, doesn't it? Something is done.

MR. LOBEL: But that's not enhancing or decreasing pressure. Let me just say. The point I was trying to make is nothing new is being done in terms of those things. The operator is still reducing pressure. He just has a different point at which he has to stop reducing pressure. He has to make sure the pressure doesn't get below a certain value.

MEMBER SIEBER: That's new. As far as the operator is concerned, that's new. Right?

MR. LOBEL: That number is new.

MEMBER SIEBER: Yes.

MR. LOBEL: Conservatism. I'd like to spend a little time on conservatism. The available NPSH is calculated for a design basis accident. Therefore it has to be done conservatively. The assumptions are done with assumptions that minimize the available NPSH and other assumptions maximize the required NPSH.

There's a concern when performing design basis analyses that the results shouldn't be skewed to the extent that they become misleading. And it's become apparent during this reassessment that this is a possibility in this case that perhaps the analyses at least in some cases are done with a degree of conservatism that skews the results to conclude the containment accident pressures necessary and must be credited when "a more realistic but still conservative," those words, analysis may not reach that conclusion.

This isn't unique. Statistical LOCA analysis, statistical DNBR calculations are done defining the conservatism but they're done and the reason they were done is so that the conservatism, the results don't get unrealistic to too great an extent.

The next slides I've listed some of the conservatisms that go into these analyses and I thought I'd go through them for the BWRs but I also listed them for the PWRs. Some of them are the usual design basis things.

CHAIRMAN WALLIS: There's a tech spec on maximum suppression pool temperatures.

MR. LOBEL: Usually. Right.

CHAIRMAN WALLIS: So if they have a leaking valve or something that's heating up the pool, they have to take some action to cool the pool.

MR. LOBEL: Right. They are not supposed to let it go above 95 degrees. If it does, then they have to start suppression pool cooling. If it goes above 110, then they have to shut down the reactor.

Reactor power is 102 percent. That's a guidance from Reg Guide 1.49 that people follow for design basis accidents. The decay heat is at the two sigma level. That's something that's usually done for design basis accidents and we've required it.

CHAIRMAN WALLIS: Well, if we're worried about two percent on reactor power, we ought to really worry about 20 percent.

MR. LOBEL: Yeah, this is a substantial one. This is worth a good deal in terms of conservatism.

CHAIRMAN WALLIS: It is? But with an up rate to 20 percent?

MEMBER KRESS: I think then it would be 122 percent of the original power. You would still add the two percent on top of that.

CHAIRMAN WALLIS: If you're worried two percent being overly conservative then 20 percent sounds like an awful lot more.

MR. LOBEL: No, I thought you were on the next one, the two sigma.

CHAIRMAN WALLIS: No, I was on the two percent, not the two sigma.

MR. LOBEL: Okay.

MEMBER KRESS: The two percent is not much of a conservatism.

VICE CHAIR RANSOM: In the interpretation, that would be 102 percent of a 120 if you were on an upgraded system.

MR. LOBEL: The decay heat's based on operation that bounds a specific operating cycle. So you would expect to have a higher decay heat than you would for any specific cycle. Of course, you take the worst single failure which is either loss of a diesel or loss of an RHR heat exchanger.

The initial drywell/wetwell temperatures and pressures and relative humidities are selected to minimize the accident pressure. So you would maximize the humidity, say, and that would give you for the same total pressure that gives you less air which gives you less accident pressure when you heat up the air. All these kinds of things are determined in the conservative direction.

The suppression pool temperature is the tech spec maximum. The initial surface water temperature is at the tech spec maximum. The initial suppression pool water volume is the minimum allowed by technical specifications and this maximizes the suppression pool temperature. It also gives you less positive head for the available NPSH and it also lowers the containment pressure. So this is an example of a conservatism that increases the temperature and decreases the pressure.

The containment sprays are available to cool the containment. They're initiated at 600 seconds and operate continuously with no throttling of the RHR pumps below rated flow. This is conservative in the sense that you could get the same suppression pool cooling in a BWR by operating the RHR pumps in the suppression pool cooling mode without the sprays, but you wouldn't reduce the pressure in the drywell and the wetwell. So by operating the sprays, you're getting the same cooling but you're reducing the pressure.

The passive heat sinks are modeled. The liner in the containment and the concrete in the containment, the internal structures are modeled to reduce the heat transfer to them and that reduces the containment pressure. The feedwater flow in the vessel --

MEMBER SHACK: That's not a conservatism. You have to do that. Right?

MR. LOBEL: You don't do that for the peak calculation.

MEMBER SHACK: Okay, but that's because I'm being conservative on the other side for that one.

MR. LOBEL: Yeah.

MEMBER SHACK: But I mean for this one, I certainly do need to.

MR. LOBEL: You do need to consider it and you usually not only pick a heat transfer coefficient that would model that but you usually exaggerate the heat transfer coefficient. The guidance for PWRs for minimum pressure is to take the usual heat transfer coefficient for heat transfer of the containment atmosphere to the liner and you multiply it by a factor of four. So I try to give myself more heat transfer to the structure than I normally expect.

MEMBER SHACK: But that guidance comes out of Appendix K calculations. Right?

MR. LOBEL: The requirement to do a minimum pressure calculation is Appendix K.

MEMBER SHACK: Where does the factor of four come from?

MR. LOBEL: That's from the standard review plan.

MEMBER SHACK: Okay. Now would that apply to this calculation?

MR. LOBEL: I'm not sure. To be honest, I'm not sure off-hand. I don't remember. I was going to look that up and didn't whether they use the factor of four for BWRs. Maybe somebody in the audience knows. I'm not sure.

MEMBER SIEBER: In any event, there's a substantial amount of BTUs that are removed by that mechanism.

MR. LOBEL: It's an important effect and

until you turn on the sprays. Once you turn on the sprays, the sprays kind of overpower this effect anyway.

MEMBER SIEBER: Overwhelm.

MR. LOBEL: So it would be important for the first 600 seconds.

MEMBER SIEBER: Okay.

MR. LOBEL: The feedwater flow into the vessel continues after the accident until all the feedwater which would increase the suppression pool temperature is added and then you assume the feedwater flow is terminated. So you only have feedwater flow into the vessel and out into the suppression pool when it's going to heat the suppression pool but not after.

CHAIRMAN WALLIS: This feedwater when you're operating, it's presumably preheated.

MR. LOBEL: Right.

CHAIRMAN WALLIS: But when you shut down, it's not longer preheated. Does it come from a tank where it's already --

MR. LOBEL: Yes, you could probably stop the heating, but I would imagine it would take a little while -

CHAIRMAN WALLIS: And there's perhaps a tank that stores hot feedwater.

MR. LOBEL: You have the structures that would still be warm, still be hot.

MEMBER SIEBER: The biggest impact though is the hotwell temperature. It will go down to that pretty fast.

MR. LOBEL: The horsepower from the core spray and RHR pumps is all assumed to go into heating the suppression pool so that there is some loss of efficiency from the motor to the pump and you don't account for that. You assume that all the energy from the motor is going into heating the suppression pool. The efficiency of the heat transfer between the drywell air space and the liquid break flow was chosen to minimize the containment pressure. So you make assumptions of the efficiency of the heat transfer between the break flow and the drywell atmosphere.

CHAIRMAN WALLIS: I should think the pump is going to have -- This is suppression pool water. The other inefficiency is the pumps and break horsepower is presuming the power delivered to the water. But there's also heat delivered to the water by friction in the pump itself which doesn't show up as break horsepower. It's not a very big number but it's more than just break horsepower.

MR. LOBEL: No, it's about 15 percent of

the total horsepower. Okay. A single value of the suppression pool level was chosen for the available NPSH calculation and the value that's chosen is less than the calculated value of the suppression pool level at the time of peak suppression pool temperature. So not only have I done a calculation to minimize the level of calculating for the suppression pool but I picked a level even below that to use for the NPSH calculation.

The pump flow. I talked about this before. The pump flow used in the NPSH calculation is greater than the pump flow assumed in the LOCA and peak cladding temperature calculations. The other assumption is that the flow is not throttled. This pump flow continues for the whole accident and when you consider that the peak suppression pool temperature in a BWR is sometimes in the range of six to eight hours, that says that the operator is going to keep the pumps going at this high capacity for a much longer time than they probably would.

MEMBER SIEBER: He's waiting for shift change.

MR. LOBEL: Especially now because you have to consider that at this point most likely the core level is being maintained with a core spray pump and the RHR pump is only being used for cooling the suppression pool. Although if you assume you have both trains of RHR, you might be injecting with one train of RHR and using the other one to cool the suppression pool.

The debris head loss is bounding.

CHAIRMAN WALLIS: NPSH is measured with cold water and we had this discussion with Bill Sherman that apparently the way the temperatures take in account of is in a term which has the vapor pressure of the water in it which is on the right-hand of that equation instead of the left.

MR. LOBEL: The required NPSH depends on two things. It depends on temperature and flow. The requirement NPSH increases with flow and typically the value that's chosen is a maximum value.

CHAIRMAN WALLIS: But with temperature it's more likely to cavitate with hot water.

MR. LOBEL: With temperature the required NPSH goes down. It actually decreases with increases -

CHAIRMAN WALLIS: It's very strange. You need more over-pressure with hot water as a prevented boiling.

MR. LOBEL: It's two thermodynamic

properties. It's the specific volume -

CHAIRMAN WALLIS: So the vapor pressure is taken account of in some other part of the equation. Isn't that what this is?

MR. LOBEL: Yes, in his equation, he combined two terms to the other. So he didn't show the vapor pressure. But in the NPSH calculation, there is a positive term for atmosphere and a positive term for the height of water, a negative term for the losses and then a negative term for the vapor pressure.

CHAIRMAN WALLIS: If you had boiling water coming in, it would have no NPSH.

MR. LOBEL: If you have boiling water come in, the only thing you would have is the height of the water. That's the PWR assumption if you assume that the pressure is the saturation pressure. What that does is it cancels the first and the last terms. You have a positive atmospheric pressure and a negative vapor pressure.

CHAIRMAN WALLIS: So this correction is made for reduction and requires the NPSH for the temperature.

MR. LOBEL: Yes, that's a different thing.

CHAIRMAN WALLIS: That means that it's,

say, 32 feet for this reference plant and that's on the left-hand side which you call NPSH and the effects of vapor pressure are taken account of on the right-hand side somehow.

MR. LOBEL: Yes.

CHAIRMAN WALLIS: But there are some other effects. What's the reduction then? What's this reduction?

MR. LOBEL: The reduction in required NPSH is if I -- The tests that determine required NPSH that the pump vendor does are done with cold water. When these pumps are operating during an accident, they're pumping hot water and the required NPSH decreases.

CHAIRMAN WALLIS: Just slightly because of density change.

MR. LOBEL: No, it's two things. It's the specific volume and the heat of vaporization decreases. So those two effects actually give you smaller bubbles and it's harder to make the bubbles. So the required NPSH actually decreases as the temperature goes up and there are curves --

CHAIRMAN WALLIS: Is this based on mass flow rate or volume flow rate? Well, I guess we don't want to get into this.

MR. LOBEL: It's just the properties.

CHAIRMAN WALLIS: If you want to pump the same mass, you're going to have a higher velocity at lower density. You're going to have a bigger row of V squares.

MEMBER SIEBER: Yes, like positive displacement.

MR. LOBEL: Pumps pump volume.

CHAIRMAN WALLIS: But you cool with mass. Anyway, forget that.

MR. LOBEL: Right.

CHAIRMAN WALLIS: This always bother me this talking about gallons per minute when what you're really interested in is mass flow of stuff.

MEMBER SIEBER: That's why you're an engineer to figure that out.

CHAIRMAN WALLIS: You might have to explain what's going on here in a bit more detail if it ever gets really examined.

MR. LOBEL: Okay.

MEMBER SIEBER: A pump is a volumetric device.

MR. LOBEL: Right. There are curves in the hydraulic institute standards that provide corrections to actually lower the required NPSH with temperature. The reg guide has the guidance that you shouldn't do that but that should just be treated as a conservatism and actually there are some papers written by some pump experts. Korasic who wrote the pump handbook has a paper where he recommends that that be just kept in the pocket as margin and not taking credit for.

There are also some restrictions in the hydraulic institute standard on when you should take this credit and how much you should take and that kind of thing. So our guidances just don't use it.

VICE CHAIR RANSOM: This is a contrast to the available NPSH which is being reduced by the increase in temperature.

MR. LOBEL: Right. My available is going down. If I let my required go down, I would be giving myself more margin than I am. I'd keep the required where it is. Let me see. A minimum number of ECCS pumps is assumed used to inject into the reactor vessel. What this does is it results in a slower cooling of the reactor coolant so more heat's added to the suppression pool sooner. The RHR heat exchanger's effectiveness is minimized by assuming --

CHAIRMAN WALLIS: Okay. So you've told us that you've done 15 good things here, but we have no idea how important any of them are. Yeah, I do. I have some --

CHAIRMAN WALLIS: It would really help if there were some sort of numbers on these. Because you can say I'm conservative, I've done all this stuff, all of these are conservative, but how much do you really -- by each one of these things. We don't know, do we? You probably know.

MR. LOBEL: I know some. I'm sure the people who do these calculations do.

CHAIRMAN WALLIS: Some of these may have almost no effect at all.

MR. LOBEL: Some of them don't have a lot of effect. That's true. Some of them have more effect some places than others.

CHAIRMAN WALLIS: Right, but are they increasing your margin by 0.01 percent or 50 percent or something? That's the sort of thing one would like to know when one's being conservative, how much are you really buying --

MR. LOBEL: Let me give you a few examples that I have. These aren't all in terms of NPSH. For example, a five percent degree change in initial suppression pool temperature gives approximately a one degree change in the peak suppression pool temperature. One hundred and two percent versus 100 percent power gives you about a one degree Fahrenheit suppression pool temperature increase. Let me see if I have some other good ones.

CHAIRMAN WALLIS: So the more effective measures give you something a degree.

MR. LOBEL: For the decay heat, if I use a nominal decay heat value I have a suppression pool temperature 1074 degrees. If I add a ten percent uncertainty to that which approximates the two sigma it's 179 degrees.

CHAIRMAN WALLIS: That's a big effect, that one.

MR. LOBEL: Yeah. The containment leakage, if my containment leakage is 1.6 mass percent per day which would be the L_a value, that's only worth about a 0.1 PSIG reduction. So leakage doesn't buy you a lot. The mixing of the break flow with the containment atmosphere is significant. If I have a mixing fraction of 20 percent, if I say that 20 percent of the break flow mixes with the containment atmosphere, that gives me a pressure of approximately 2.9.

CHAIRMAN WALLIS: Okay. So there are some nonconservatism. You're assuming that all of the main steam isolation valves shut perfectly.

MR. LOBEL: I'm sorry. They what?

CHAIRMAN WALLIS: Main steam MSIVs, main steam isolation valves, you assume that they close perfectly.

MR. LOBEL: Even if I assume, if I take a single failure in one, they're redundant.

CHAIRMAN WALLIS: But how big? If it's open wide, it's a big hole, isn't it?

MR. LOBEL: If one failed to close, I have the other. If both failed --

CHAIRMAN WALLIS: You mean two in series?

MEMBER SIEBER: Yes.

MR. LOBEL: Yeah.

CHAIRMAN WALLIS: Then okay. I just wonder but your assumption assume that they all close or they assume the only one in series closes so essentially the path is blocked for flow.

MR. LOBEL: Are you talking in terms of leakage?

CHAIRMAN WALLIS: Yeah.

MR. LOBEL: Yes, you would assume that would be included. The MSIV leakage is included in this number.

CHAIRMAN WALLIS: How big is a conservative leakage of MSIV?

MR. LOBEL: I can't think of them in consistent units.

CHAIRMAN WALLIS: I just bring this up because it was brought up in the other presentation we heard where supposedly several MSIVs were leaking in this reference plant.

MR. LOBEL: Typically, leaking isn't going to have much of an effect.

CHAIRMAN WALLIS: It's a very small flow rate?

MR. LOBEL: Yeah.

CHAIRMAN WALLIS: I remember TMI had a leaking pore and it got worse and worse from day to day and it was way beyond specs and it contributed to the accident.

MR. LOBEL: This would be leaking after the accident when the pressure would be approximately the containment pressure and TMI was --

CHAIRMAN WALLIS: I know but I was just saying there was a leaking valve and it wasn't much of a leak but it got worse and worse and ended up contributing.

MR. LOBEL: Yeah. But there are two and leakage like you see doesn't have a really big effect and when they do these calculations, they include the tech spec value of the MSIV leakage.

CHAIRMAN WALLIS: Oh, that's included, is it?

MR. LOBEL: Yeah. The tech spec value, if they're leaking more than that, obviously it wouldn't be.

VICE CHAIR RANSOM: I wonder if we could get these conservatism examples that you have converted to available NPSH and feet.

MR. LOBEL: Sure.

VICE CHAIR RANSOM: And that should be easy to do.

MR. LOBEL: Well, the problem is what I did was pick things I could find from different analyses, different submittals, and so they're not all consistent. I think the report that the State of Vermont was referencing, they included some tables of sensitivities. That's probably the best source of, most complete source of things. Unfortunately, it's not something that we get some licensees. I'm sure licensees do a lot of this, but we don't have --

VICE CHAIR RANSOM: Where did you get the temperature effects that you quoted? Are those based on calculations?

MR. LOBEL: Different submittals.

VICE CHAIR RANSOM: Oh, submittals.

MR. LOBEL: Yes, they're based on licensee calculations from different submittals. I can give you what I have but that's not in terms of NPSH.

CHAIRMAN WALLIS: You're going to get onto debris.

MR. LOBEL: Well, I'm --

CHAIRMAN WALLIS: I'm concerned about debris and you say something about ten minutes. We looked at tests, several tests, and it appears that the pressure drop across a strainer even when you have the same stuff there increases with time.

MR. LOBEL: Right, and what this says is -- This is kind of long but what this says is for the short term, less than ten minutes, I use the value at ten minutes.

CHAIRMAN WALLIS: At ten minutes. So you're being conservative building up.

MR. LOBEL: Right. And then after ten minutes, I'm assuming a different single failure maybe and I am assuming a single different failure and I may have a different number of pumps operating and they'll be operating at a different flow rate. So what's done is at least in one case is the debris is redistributed. So any strainers that don't have flow through them for the long term, that debris is taken off and it's put on the strainers --

CHAIRMAN WALLIS: Is there any possible mechanism for that happening?

MR. LOBEL: No.

CHAIRMAN WALLIS: So someone with a shovel, breaks it off the strainer that has no flow through it and pumps it on the other strainer.

MR. LOBEL: Maxwell's demon. But there are a lot of these kinds of conservatisms.

CHAIRMAN WALLIS: You could also say that the material which is supposedly hung up in pools above somewhere never gets to the sump suddenly comes down and there are all kinds of things you could do be conservative.

MR. LOBEL: There's a conservative assumption that's made where I treat the power as a step that's above the continuous curve just because it's simpler to do the calculation that way.

CHAIRMAN WALLIS: This is what you do. What does an applicant do? Do they all do the same things you do?

MR. LOBEL: Well, I'm talking about what they do.

CHAIRMAN WALLIS: You're talking about

what they do.

MR. LOBEL: We don't do these calculations.

CHAIRMAN WALLIS: You're talking as though you were the guy doing the calculations.

MR. LOBEL: No, I'm sorry. I shouldn't say that. No.

CHAIRMAN WALLIS: Now is this consistent right across the industry? They all do this or is there a whole mix of things that they do?

MR. LOBEL: There is a mix to some extent but for the BWRs, it's fairly consistent.

CHAIRMAN WALLIS: Is that because there's some sort of a guidance document that they developed themselves?

PARTICIPANT: Yes.

CHAIRMAN WALLIS: Yes.

MR. LOBEL: Well, it's probably not they might have a guidance document. It's more that typically these calculations are done by one organization and they have their way of doing it.

CHAIRMAN WALLIS: Like some of the people who were sitting up at the back earlier today perhaps.

MR. LOBEL: Could be. They were invited.

CHAIRMAN WALLIS: Right.

MEMBER SHACK: But you're confident, Dr. Wallis, that the calculation of debris head loss is bounding.

CHAIRMAN WALLIS: I'm not confident at all about any of these calculations until I see them.

MR. LOBEL: When we're talking about the BWRs, we're talking about the calculations that are done in accordance with the URG and the staff SERs.

CHAIRMAN WALLIS: Right.

MR. LOBEL: At one time, they were considered bounding.

MEMBER SHACK: The NC jet model.

MR. LOBEL: I guess they're officially still considered bounding.

CHAIRMAN WALLIS: Okay.

MR. LOBEL: I'll skip the PWR conservatism.

CHAIRMAN WALLIS: Is there anything unusual here? They're just about the same.

MR. LOBEL: Pretty much the same. The flood level.

CHAIRMAN WALLIS: The worst possible pipe occurs, I notice you use that. That's the biggest break.

MR. LOBEL: Yes, the biggest break in the worst location for the containment peak pressure calculation the pump suction break is usually the most limiting break.

CHAIRMAN WALLIS: Do you assume here to be conservative? That the break discharges directly into the sump and doesn't heat the containment at all?

MR. LOBEL: Essentially.

CHAIRMAN WALLIS: That's short of remarkable.

MR. LOBEL: What you assume is you have a break flow that's some liquid and some vapor.

CHAIRMAN WALLIS: You put the vapor in the containment.

MR. LOBEL: A vapor is in the containment atmosphere. A portion of the liquid flashes and stays in the containment atmosphere.

CHAIRMAN WALLIS: And all the liquid falls?

MR. LOBEL: And all the liquid falls directly to those --

CHAIRMAN WALLIS: But you don't put the steam in the sump too.

MR. LOBEL: No, not directly. There is heat transfer with the atmosphere in some cases, but in some cases, the sump temperature is hotter than the containment atmosphere. So that wouldn't be conservatives. The flood level is calculated in a way that the real level is underestimated in one calc.

CHAIRMAN WALLIS: And the industry is happy taking all of these conservative assumptions perhaps because it didn't hurt them in the past?

MR. LOBEL: Yeah, it didn't in the past.

CHAIRMAN WALLIS: When it begins to hurt, then they try to figure out how to do --

MR. LOBEL: It didn't hurt them in the past and now we're getting into debris. For the PWRs, we're talking about GSI-191 now and --

CHAIRMAN WALLIS: Here we're not.

MR. LOBEL: And they're starting to look at that and it may be hurting them. There have been some preliminary discussions with PWR licensees about crediting overflow. So I guess the message at the bottom line is that not only do we have this list of conservative assumptions but these analyses are done in a way that all these assumptions are assume to occur at the same time, that you get the most limiting break, that the parameters specified in the tech specs are all at their limiting values at the same time, that the worst single failure, not any failure, but the worst single failure occurs and that every physical process takes place in the most limiting way.

CHAIRMAN WALLIS: I hate to bring it up. I said I wouldn't talk about 191 but are you really being conservative about the debris?

MR. LOBEL: In 191?

CHAIRMAN WALLIS: No. You have all these conservatisms but the debris could be a big contributor to loss of NPSH and it's not clear that you have said anything conservative about your treatment of debris here.

MR. LOBEL: Well, I've been trying.

CHAIRMAN WALLIS: You spread it over the whole area, but --

MR. LOBEL: I've been trying to say as little as I can about debris because it's really kind of outside of the scope of this meeting.

CHAIRMAN WALLIS: Well, maybe we could say we don't quite know yet how to be conservative about debris except that it's distributed over the entire area.

MR. LOBEL: I think there are people here who could answer that better than I'd rather answer it.

CHAIRMAN WALLIS: So let's put that for another day and just bear in mind.

MR. LOBEL: I prefer to do that.

CHAIRMAN WALLIS: We're not quite clear how to be conservative about debris. We agree on that.

MR. LOBEL: I don't want to agree to that.

MEMBER SHACK: Certainly not up to me.

MR. LOBEL: Yes, it's not up to me to agree or disagree. It's not my issue.

CHAIRMAN WALLIS: Okay. If you knew how to, you'd be as conservative about debris as you've been about all these other things. Right?

MR. LOBEL: Yes.

MEMBER SHACK: The intent is to be conservative.

MR. LOBEL: Yes. The intent is to be conservative.

CHAIRMAN WALLIS: Bounding. That's bounding to you.

MR. LOBEL: Bounding. Yeah.

CHAIRMAN WALLIS: And you don't worry about conservatisms which are inherently incompatible with each other if there are such things.

MR. LOBEL: No. For instance, I was going to say in the PWR in determining the level I saw one calculation where the level is calculated based on a small to intermediate size break because that gives you less water on the floor. But the rest of the calculation is for a large break LOCA. So they're not --

CHAIRMAN WALLIS: The level is calculated assuming no water goes there and the temperature is calculated assuming all the water goes there.

MR. LOBEL: Yeah. There are reasons for this. One of the reasons that comes up every once and a while is a licensee will find an error in the calculation and they'll have to come in and they'll say, "We found this error but it's okay for us to continue to operate because look at all this other margin we have." So they like to have some extra margin in these calculations. I'm not sure that they would want to do a realistic calculations either.

MEMBER SHACK: It's hard to do a half conservative calculation.

MR. LOBEL: That's true.

MEMBER SHACK: Once you introduce things that aren't conservative, then life really gets exciting.

MR. LOBEL: That's right. That takes work and a level of knowledge that may not be out there right now.

CHAIRMAN WALLIS: It's like politics. There's no half conservative.

MR. LOBEL: Not anymore. Pump design. I'm sorry. I skipped the most important. Statistical method. We've been kind of talking about this.

CHAIRMAN WALLIS: Yes, this sounds good.

MR. LOBEL: One of the positions that we put into the reg guide was a possible solution of using a statistical method just like you've been talking about, Dr. Wallis, of identifying the uncertainties, quantifying the uncertainties and treating them in a statistical way which has the advantage of knowing what your level of conservatism would be, at least better defining it than what we have now. As I've said, we've had some preliminary discussions but nobody's tried this yet.

CHAIRMAN WALLIS: If all these are really conservative and bounding, then they're essentially saying there's no probability of this happening.

MR. LOBEL: Essentially yeah.

CHAIRMAN WALLIS: So this would be a relaxation.

MR. LOBEL: It would. It would be a relaxation and it would have the advantage that if it predicted that you needed containment pressure, you'd have a pretty good confidence that you needed it.

CHAIRMAN WALLIS: Has anybody done this?

MR. LOBEL: No.

CHAIRMAN WALLIS: It's interesting to see. The conservative stuff may predict 30 feet, whatever, pick a number. It may well be that, this method here you're indicating, might predict 300 feet. It may be they're so conservative now that they're way off. I just have no idea.

MR. LOBEL: You know the ESVWR uses track G to do the containment and the reactor calculations in a combined fashion. So it may be possible to get some sense out of that calculation when we see that application at some point.

CHAIRMAN WALLIS: So they're going to do it this way.

MR. LOBEL: They're going to use track G and track G is set up to be able to do statistical uncertainty calculations, although they haven't quite done it but it's possible. So right now, this is just a position that was put into the reg guide with the hope that --

CHAIRMAN WALLIS: I don't like the word "nominal calculation." What it should be is "realistic calculation." But nominal to me means something pulled out of the air.

MR. LOBEL: Okay. Well, I was using it in the sense of --

CHAIRMAN WALLIS: Almost pejorative.

MR. LOBEL: I guess it's realistic. Without any uncertainty.

MR. CARUSO: Best estimate.

MR. LOBEL: Best estimate, yeah. So we could take whatever you call it and then you would add the uncertainties on it, some statistical and upper tolerance limit that you picked.

MR. CARUSO: Don't you still have to look at a spectrum of scenarios though?

MR. LOBEL: Yeah. You'd still have to do that and then of course you'd have conservatism.

MEMBER SHACK: You really want to have the margin I suspect to try this.

MR. LOBEL: You would. I imagine you would still pick the worst break and the worst single failure and then do something like this.

CHAIRMAN WALLIS: Ah. You're allowed to look at the probability of the break size. Then you could really do well.

MR. LOBEL: You could do that I suppose.

CHAIRMAN WALLIS: You would really be 99

percent confident. Maybe that's what you should do.

MR. LOBEL: Maybe. Honestly, this hasn't been given a lot of thought by the staff either. What we were hoping is that somebody would be attracted enough by this to try to do it and we would work with that organization together and try to define a method. This isn't a method. This is just a criterion.

VICE CHAIR RANSOM: When do you suspect 50.46 will appear to this if you go to this transition break size?

MR. LOBEL: Smaller breaks probably would make this pretty much, the need for over-pressure would probably go away I would imagine.

CHAIRMAN WALLIS: It depends on what's required beyond transition break size.

MR. LOBEL: Yeah, but if then beyond the transition break size you can do a realistic calculation, it may still go away.

VICE CHAIR RANSOM: For the mitigation phase --

MR. LOBEL: If you can assume I have all my trains of ECCS and the pumps are pumping at their design rate and not at some run-out rate and the temperatures are closer to what you'd really expect, what you'd measure experimentally.

Pump design. Let me speak a little bit about pumps not that we haven't been doing that all along. But the pumps that we're discussing, the ECCS and containment spray pumps, all have certain characteristics that are important relative to NPSH in common.

Like I was talking about a little before, the pumps are typically slightly above the low suction energy level as defined by the hydraulic institute. High suction energy indicates a pump more prone to cavitation damage than a lower suction energy pump. I don't believe any of these pumps are anywhere near high suction energy level which would be very prone to cavitation damage according to their definitions and there are curves of this in hydraulic institute standards to determine where you are and to make a decision in terms of required NPSH and the speed of the pump and like I said, the diameter of the eye of the impeller and things like that.

MEMBER SIEBER: These are typically 1800 RPM pumps.

MR. LOBEL: Typically, yes. 1750.

MEMBER SIEBER: Yeah, whatever the slip is.

MR. LOBEL: Some are around 3750

typically.

MEMBER SIEBER: That would be unusual though.

MR. LOBEL: Yeah, most of them are around 1750.

VICE CHAIR RANSOM: The energy measure that you're using is kinetic energy of the inlet flow?

MR. LOBEL: To tell you the truth, I'm not sure exactly what it is. It's described in a paper that I read as the tendency of the fluid to flash. But it's not defined in thermodynamic properties. It's defined in terms of the speed of the pump, the diameter of the eye of the impeller of the pump, the specific gravity of the fluid and something called the suction specific --

CHAIRMAN WALLIS: I think it's mostly you have to get the fluid into the pump through a hole and the hole is too small. You have to have too high of a velocity.

MR. LOBEL: Right.

CHAIRMAN WALLIS: So you have a depressurization.

MR. LOBEL: Right. That's what really is happening anyway. That's the mechanism. That's almost the definition of NPSH. You need a certain pressure, a certain head, at the suction phalange so that when you go through all these pressures losses, when you get to the impeller, you still have --

CHAIRMAN WALLIS: But some pumps don't have to escalate the flow in order to get it into the pump as much as other pumps do.

MR. LOBEL: Right.

VICE CHAIR RANSOM: I'm wondering if this isn't equivalent to what they call the thermodynamic head and pumping cryogenic type fluids.

CHAIRMAN WALLIS: That's a hot head.

VICE CHAIR RANSOM: It's more of a fluid properties effect.

MR. LOBEL: There's a tradeoff. One of the tradeoffs is since one of the factors is the diameter of the eye of the impeller if I make that smaller I lower the level of energy going in and so that helps. But then that has other disadvantages. If I make that diameter larger, I'm in --

VICE CHAIR RANSOM: It must not be kinetic energy because the kinetic energy would increase as you make it smaller.

CHAIRMAN WALLIS: I think you want to make it big.

MR. LOBEL: Yeah.

MEMBER SIEBER: It depends on the head and the flow characteristic that you want. There's a balance.

MR. LOBEL: There's a lot of tradeoffs in this and this all gets into the design of the pump which is the pump vendors.

VICE CHAIR RANSOM: Is this defined anywhere?

MR. LOBEL: It's defined in some hydraulic institute standards, the one on margin. I can give you a copy of it.

MEMBER SIEBER: Basic stuff is in Mark's handbook.

MR. LOBEL: Is it somewhere in Mark's?

MEMBER SIEBER: Yes, there are sections on pump. I take it these are verticals, the bulk of them. I know some that aren't, but they're vertical shaft.

MR. LOBEL: The BWRs, almost all.

MEMBER SIEBER: The PWRs?

MR. LOBEL: The PWRs, I think there's more of a variety but I know some of them are.

MEMBER SIEBER: Yeah, that's the easy way to see draft because you just dig a hole in -- and line it and you can go pretty deep as opposed to building a room down there.

MR. LOBEL: This table is just to show that stainless steel is a fairly good material to use for the pump impellers and pump casings that it's fairly cavitation resistant.

MEMBER SIEBER: Right.

CHAIRMAN WALLIS: Two is good?

MR. LOBEL: It's a relative thing.

CHAIRMAN WALLIS: All the numbers are good.

MR. LOBEL: It's not below list.

MEMBER SIEBER: Actinium is also good. Plastic is not.

MR. LOBEL: Titanium and aluminum bronze.

CHAIRMAN WALLIS: But this is over a long period of time, isn't it?

MR. LOBEL: Right.

CHAIRMAN WALLIS: You're not going to run this thing for a year in cavitational condition.

MR. LOBEL: Right. That's a good point and that's what I was trying to get at.

CHAIRMAN WALLIS: Cavitational peril sounds really dramatic.

MEMBER SIEBER: But if you get a lot of destructive cavitation, then material becomes important even in a short period of time.

MEMBER SHACK: Another unquantifiable conservatism.

MR. LOBEL: The next table --

CHAIRMAN WALLIS: You haven't talked about the particular content here. You talk about a gas content is low as you're pumping stuff with finely divided Calsil particles or something. Did it change anything about it or not?

MR. LOBEL: I'm sure it --

CHAIRMAN WALLIS: I asked that earlier.

MR. LOBEL: Yeah. I'm sure it wouldn't do the pump a lot of good. I don't know what the effect on cavitation would be.

CHAIRMAN WALLIS: You might see if there's any information. When you come for a full committee you could answer that.

MEMBER SIEBER: There's an interesting thing though. When you consider pumps of all types even in power plant if you go to water treating, you'll find that they dewater the clarifier which is a big settling pond. That stuff is like mud, but they pump it and the way they protect the pump is to use rubberized water cooled bearings where you supply fresh water to it. And so there are multiple designs of heat draft pumps that provide you with varying degrees of protection from debris. You can pump sludge. You can pump coal, believe it or not.

CHAIRMAN WALLIS: You can pump coal but you have to have the right design of pump.

MEMBER SIEBER: I think it helps to have the right design for each application.

MR. LOBEL: And material for the impeller.

MEMBER SIEBER: Right. Coal pumps don't last long.

CHAIRMAN WALLIS: So hardness isn't necessarily the right criterion for wear in this context. So these rubberized pumps --

MEMBER SIEBER: You may recall a plant in the Midwest who had a horizontal shaft pump that suffered a lot of bearing damage due to sump debris. That didn't have the protections that some other types of pumps have and so that's unique to each individual plant. It depends on the pump design, the kind of pump that it is and whatever built-in protections it may have.

MR. LOBEL: Let me go on. The next table --

CHAIRMAN WALLIS: This is quite remarkable. I mean you have two foot required for mark three and you have almost 30 foot required for some of the mark ones.

MR. LOBEL: Well, that's the message I'm trying to --

CHAIRMAN WALLIS: So you could just put a mark three function in a mark one.

MEMBER SIEBER: No.

MR. LOBEL: You can see that the message I'm trying to make that this is really mostly a problem for the older BWRs that as plants evolved they realized, I guess, they needed to do something about this.

CHAIRMAN WALLIS: What happened to this mark one at the bottom? It has a much lower.

MR. LOBEL: It's a newer mark one if you look that CP issue date.

CHAIRMAN WALLIS: Oh, it's a '74.

MR. LOBEL: Yeah.

CHAIRMAN WALLIS: So that shows that a mark one can have a pump. Does it take more space or something? Can have a pump with a lower NPSH-r.

MR. LOBEL: Sure. That's what this shows.

CHAIRMAN WALLIS: So could Vermont Yankee, let us say just as an example, put in a pump with a lower NPSH-r like this?

MR. LOBEL: I don't want to answer them. I don't know.

CHAIRMAN WALLIS: We don't know. One could ask since another mark one has it. What's the CH --

MEMBER SIEBER: Only the licensee could answer that.

MR. LOBEL: Yeah. I'm sorry. What?

CHAIRMAN WALLIS: I'm sorry. I was just -- Two feet is quite an achievement, isn't it?

MR. LOBEL: The BWR 5 and BWR 6 product lines and later BWR 4s use pumps designed to handle saturated fluid. So they won't require accident pressure credit. The industry was going in the right direction. I guess the newer plants now don't have pumps, the new designs, safety related pumps.

CHAIRMAN WALLIS: The new designs which the flow occurs by gravity are totally dependent on NPSH because it's the gravity that does all the work.

MR. LOBEL: They're dependent on gravity.

MEMBER SIEBER: You end up with other issues like you have to depressurize the plant in order to make gravity work.

MR. LOBEL: You need a suppression pool or something.

MEMBER SIEBER: And it has to be very tall.

MR. LOBEL: Okay. You have approved credit for operation under cavitation below the required NPSH with and without credit for containment accident pressure based on the pump cavitation testing. The pumps are tested for a period of time and then they are disassembled and the insides are examined, the pump shafts, sleeves, bearings, seals.

CHAIRMAN WALLIS: The test also tests their ability to provide the flow.

MR. LOBEL: Right.

CHAIRMAN WALLIS: It must be there somewhere.

MR. LOBEL: That would be measured too.

CHAIRMAN WALLIS: And there's no falloff flow rate over this period of time.

MR. LOBEL: There is.

CHAIRMAN WALLIS: There is?

MR. LOBEL: In some of these tests, there is. The flow will decrease as you --

CHAIRMAN WALLIS: Now are these tests run for long enough to really show what we're looking at here?

MR. LOBEL: Some of the tests are run for periods of less than an hour, but the longest test was a test run for an older BWR where they did the witness test and then they took the pump apart and examined it and put it back together again and then they did a cavitation test. They ran the pump for an hour and then took it apart, disassembled it and examined it again and didn't see any damage. Then they put it back together again and tested it at run-out flow at more cavitation for another hour and took it apart again and didn't see any damage.

CHAIRMAN WALLIS: But you're talking about two and a half days or something, aren't you, here? In our earlier discussions, you said 55 hours or something like that.

MR. LOBEL: That's the --

MEMBER SIEBER: Pressure --

MR. LOBEL: That's the time that the reference plant --

CHAIRMAN WALLIS: They needed to have over-pressure. So we're talking about a much longer time of operation than these tests.

MR. LOBEL: Right.

CHAIRMAN WALLIS: Does that concern you at all?

MR. LOBEL: No, because they're not taking credit for operating in cavitation for all that time.

MEMBER SIEBER: The other issue is you don't necessarily run the test until the pump destroys itself. What you try to do is get all the vibration signatures and shaft whip and those kinds of things from which one can predict how long the pump will last until it fails.

MR. LOBEL: There was a test done at another BWR. They didn't specify the time but this was actually an incentive to ask where an RHR pump was operated from the suppression pool and back to the suppression pool in cavitation and they didn't specify a time but they did a lot of measurements of throttling and reducing the flow and reducing the suction flow also and seeing what the effect was and determined that operation for the time they needed it was okay.

CHAIRMAN WALLIS: Well, the slide we saw earlier said that these witness tests, some of these are the same thing, were only for too short a duration. That was the presentation from our friends this morning.

MR. LOBEL: Witness test is -

CHAIRMAN WALLIS: Is that what you're referring to in this slide?

MR. LOBEL: No, these wouldn't be witness tests. A witness test would be a test that the pump vendor runs for the customer to show to the customer that the pump will do what the customer specified. It would do these tests. It would go beyond that.

CHAIRMAN WALLIS: He probably doesn't want to run it for several days on the cavitation and conditions.

MEMBER SIEBER: The witness test is a factory test as opposed to these kinds of tests which are in the plant with small piping.

MR. LOBEL: Well, some are. Some are at the pump vendors place.

MEMBER SIEBER: Yes.

MR. LOBEL: But some of them are in the plant also. The 55 hours or whatever the time is for these is the time that they're requesting over-pressure but a lot of this time could be with not a lot of over-pressure.

MEMBER SIEBER: Two pounds.

MR. LOBEL: I don't remember the exact time for this reference plant, but some of that time, it's like one and a half PSIGs what they're asking for and with just revising one or more of these, probably any one of these, well, I won't say anybody, but some of these conservative assumptions, you could get rid of the one and a half PSIG need for over-pressure.

CHAIRMAN WALLIS: But if they were not allowed to take credit for over-pressure than in regulatory space they could be running for 55 hours and even if never really happened, but you'd have to consider them running at 55 hours with maybe severe cavitation.

MR. LOBEL: I don't know whether that would ever happen or whether like we were talking earlier today about having to come up with another approach. The impact on operation. The next area to discuss is the impact on operation. Operators have several indications of pump cavitation.

Actually, these would be from the control room operator route near the pump. There would obviously be others and there's probably others from the control room that I haven't listed here, but erratic or decreasing pump motor current, erratic flow or flow less than expected, frequent adjustments of discharge valves to maintain a constant flow would be an indication to an operator that he had some kind of NPSH problem or some problem with the pump. The flow course from a safety-related pump is something that the operator would be monitoring almost constantly.

CHAIRMAN WALLIS: I think you can get cavitation which can damage a pump without any of these symptoms. Simply local cavitation which bangs away at certain parts of the blades and doesn't change the overall characteristics very much.

MR. LOBEL: Again, yeah. You could be in cavitation but if you're not in cavitation to the point where you're decreasing the flow --

CHAIRMAN WALLIS: Then you don't care.

MR. LOBEL: Then you're probably really have a problem.

CHAIRMAN WALLIS: Right. You have to separate the damaged part from the effect on operation part.

MR. LOBEL: Right.

VICE CHAIR RANSOM: Is it all beyond the three percent point?

MR. LOBEL: These are beyond it. Yeah.

MEMBER SIEBER: Yeah, these are out at the need probably when you get these kind of symptoms.

MR. LOBEL: And the responses the operator could take would be throttling the pump, removing the pump from service.

CHAIRMAN WALLIS: That means switching it off?

MR. LOBEL: Switching it off. Utilizing another water source. The next slide is a sensitivity study I found that illustrates the effect of throttling the pump. This is a calculation for an RHR pump in a system with four RHR pumps, two in each train and two course spray pumps operating. The pump flow starts out at 5,000 GPM.

The table shows the suction loss and the suction piping going to the pump, the required NPSH and the NPSH margin. You can see if I throttle the flow to 3750 I've greatly reduced the, or I've increased the NPSH margin, but I'm still negative. I still have available NPSH than required NPSH and if I halved the flow from the starting flow, I have a positive margin. So throttling the pump is something the operator can easily do that can have a big impact.

CHAIRMAN WALLIS: I think if you throttle it too far then you get into some other condition.

MR. LOBEL: Right.

CHAIRMAN WALLIS: Where it's not very --

MR. LOBEL: And the operator would have to follow his EOPs and he'd have to make sure he's satisfying all the other conditions he needs to satisfy. But don't forget too that this is out at some long time after the accident. He's not worried at this point about injection anymore. He's trying to cool the suppression pool. So he'd have more latitude in operations to throttle the flow.

CHAIRMAN WALLIS: In the days when I used to have a shallow water well, this was exactly how I treated cavitation in my pump in my house. I would go down and throttle it and it starts to cavitate. So I know it works.

MR. LOBEL: You can see why it works at least in this case. As I lower the flow, I greatly lower the suction losses since they are pretty much based on the square of the flow and I also lower the required NPSH.

Reg Guide 1.1, we talked about this a little early, has two concerns, the containment integrity we already discussed and the possibility of cooling down the containment excessively to the point where you don't have the pressure you credited. I already went through most of this but the operating procedures currently contain operator guidance to terminate the spray flow at zero PSIG. Some BWRS, the sprays are terminated automatically at a higher flow. In plants, the credit accident pressure, the emergency operating procedures specify a higher value at which to terminate the sprays so that the credited NPSH stays available.

CHAIRMAN WALLIS: What does this maintain containment and structural integrity?

MR. LOBEL: You don't want to have a vacuum inside.

CHAIRMAN WALLIS: Oh, I see. You don't want to collapse it.

MR. LOBEL: Right.

CHAIRMAN WALLIS: Ah, because it's not designed for that. Now I understand.

MR. LOBEL: It's designed up to a certain point. I don't remember what the number is for BWRs. For PWRs, it's -2 PSIG, I think, is usually the design number for the containment.

CHAIRMAN WALLIS: But if you ran a nice condenser plant with no steam in it you might go down to quite a big vacuum maybe.

MEMBER SIEBER: It depends on the plant.

MR. LOBEL: Yeah.

CHAIRMAN WALLIS: There's no vacuum breaker on containment.

MR. LOBEL: And also the emergency operating procedures for BWRs have curves of suppression pool temperature and pump flow with containment pressure as a parameter so the operators can keep track of any containment pressure he may need for the temperature he's at in the pump flow.

CHAIRMAN WALLIS: Now you've made a very interesting presentation, very informative. We're talking about reg guide, are we? I look at it as there's a lot of changes in there. So in order for us to be satisfied, we have to very carefully review those, wouldn't we?

MR. LOBEL: Most of the changes are really editorial.

CHAIRMAN WALLIS: But they seem to be huge amounts as I said before to line out and so on.

MR. LOBEL: Yeah. Like I was saying --

CHAIRMAN WALLIS: Because of duplication.

MR. LOBEL: Yeah, you had the same discussion under BWRs and PWRs. I tried to put it all in one place. So a lot of the --

CHAIRMAN WALLIS: So there's little that's substantial.

MR. LOBEL: The only thing that's substantial, the only thing that's really change is the position. It would be the first two positions under each section.

CHAIRMAN WALLIS: So that's where we should focus.

MR. LOBEL: And the other thing is the statistical criterion, the statistical position. That's new. A lot of information was added. I don't want to give you the wrong impression. A lot of information was added in things that should be considered that I got from different sources that I thought it would be helpful to put in for people. So when they're considering the water level, say, in a PWR, there's a list of things that an analyst should consider or that a reviewer should look at to see that they were considered.

MEMBER SHACK: At least in our copy, it's not clear what's been added. It's clear what's gone.

MR. LOBEL: Is that because you can't see the redlines?

VICE CHAIR RANSOM: Yes, it's black and white.

MEMBER SHACK: Oh, I see. It's red.

CHAIRMAN WALLIS: We just have black.

MEMBER SHACK: Are we going to get an electronic version of this?

MR. CARUSO: I can give you a copy. What I did was I marked up.

MEMBER SHACK: Oh, those brackets indicate.

MR. LOBEL: Those brackets tell you what's been added.

MEMBER SHACK: Those brackets are additions. Okay.

MR. LOBEL: And you can see the strikeout.

MEMBER SHACK: I didn't know whether you were highlighting important stuff for us. Those are the additions.

MR. LOBEL: That's the non editorial additions. If you would like, I have the Adams Accessions Numbers.

MR. CARUSO: I can give you an electronic copy so you can see the red.

MEMBER SHACK: Yeah, that would be help me.

MEMBER SIEBER: That just makes our lives more complicated than they need to be.

MEMBER SHACK: I thought you gave a fairly convincing discussion of the conservatism here but when we go back to the presentation this morning, again you have your technical assistance contractor who is an NRR contractor I think.

MR. LOBEL: No, it was a research contractor.

MEMBER SHACK: Oh, tech assist.

MR. LOBEL: Yes, it was a research contract.

MEMBER SHACK: Saying that utilities --

MR. LOBEL: I believe that's true.

MEMBER SHACK: Calculations with simplifying assumptions that can't be justified. Now are these all reviewed or are these done by inspection? Is this something that comes for review before they're allowed to take this credit?

MR. LOBEL: Yes, when I licensee takes credit for containment accident pressure, we typically do a pretty careful review. I don't know what the contractor was referring to. I was involved in the review of Dwayne Arnold which is one of the cases that was cited there.

For Dwayne Arnold, we did an audit calculation. We did an independent contained two calculation, our computer code, to compare with the General Electric calculation. It was done for Dwayne Arnold and got very good comparison. And as part of doing the audit calculation, we had a contractor to do that analysis. Typically research is done, the calculations since then, for us. But as part of that review, we asked the contractor the same thing we asked researchers is to go through the input parameter by parameter and make a judgment that those values are reasonable values to use for the analysis.

Like I said, this contractor wasn't involved in the Dwayne Arnold review. I don't know where he's getting his information. I know who made that statement and I have some respect for that person. So I can't explain the comment.

CHAIRMAN WALLIS: So what you've done with the reg guide is to take all these conservative assumptions and say if you made all these conservative assumptions you may take credit for containment and over-pressure and calculating your NPSH. Is that the new position?

MR. LOBEL: Yes. Essentially and it's really been the position. But we didn't specify the concerns.

MEMBER SHACK: Are these conservatisms in the standard review plant? Is this what the review is looking for?

MR. LOBEL: I'm sorry. I should have made this clear at the beginning. What I presented as the conservatisms are conservatisms that are typically in a calculation. I'm not claiming that they're all in any one calculation, but typically the majority of them are or some other assumption. But they're typically to that level of conservatism and we review the assumptions that are made when they take --

CHAIRMAN WALLIS: So if they're conservative enough, you allow them to take credit for NMSH which is calculated using these conservative methods. That's the position.

MR. LOBEL: Yes.

CHAIRMAN WALLIS: I didn't have time to look into details on the reg guide as it changed. I was just rather taken aback by what had looked like all these changes. But I didn't have time. So that's what we will find if we read it carefully.

MR. LOBEL: Yes, that's the position.

CHAIRMAN WALLIS: And essentially, this is explicitly saying what you have been doing anyway.

MR. LOBEL: Essentially, yeah. That part of it is. The other part of the position that was changed was we had a position which we used for the 97.04 reviews that said that if you calculate at 10 PSI and you only needed 5 PSI for over-pressure, all you got credit was the 5 PSI.

CHAIRMAN WALLIS: Well, it doesn't matter.

MR. LOBEL: And it didn't make a whole lot of sense, but that was our position.

CHAIRMAN WALLIS: This is much better than the last time. The last time there's a transcript which I've seen several times but he keeps giving it back to us where we talked about this with some other of your colleagues and the message seemed to be "they asked for it and we give it to them." That wasn't a very satisfying answer. We said, "Well, don't you use criteria and so on?" We never really go down to any criteria.

MR. LOBEL: We joke with the person who told you that all the time about that. That wasn't the best answer.

CHAIRMAN WALLIS: Well, it's in the record.

MR. LOBEL: Oh, yeah, and it may have been an honest answer up to the point and again the reviewer who said that is a reviewer who did a lot of the 97.04 reviewers and she did very careful conservative reviews. The caveat is we approved whatever was asked for as long as it was done with a conservative enough analysis and we agreed with the analysis.

VICE CHAIR RANSOM: Where are we at on your presentation? We have two more presentations to go.

MR. LOBEL: I'm done except for -- Let me just make one remark about two slides and then I'll quit.

VICE CHAIR RANSOM: We are going to cover proposed reg guide methodology 1.82 or are you more or less incorporating that in?

MR. LOBEL: I thought I was --

VICE CHAIR RANSOM: And then the SRP revisions.

MR. LOBEL: I was just going to talk about -

MEMBER SIEBER: It's in.

VICE CHAIR RANSOM: It's on the agenda. So we have time.

MR. LOBEL: I've really been going through all that.

VICE CHAIR RANSOM: Okay.

MR. LOBEL: I haven't been following that agenda. Ralph, I apologize. I didn't coordinate as well as I could have with Ralph.

VICE CHAIR RANSOM: So we're doing okay somewhat.

MR. LOBEL: So I'm done except I could make just a couple fast remarks about two tables and then turn it over to Marty for the rest of it on risk. All I wanted to say, let's get onto the risk part and all I was going to say is ACRS has asked the question a couple times about looking at other events. So I made up two tables, one for BWRs and one for PWRs that listed some other events and whether there was a high suppression pool temperature, whether debris were generated and whether accident pressure was necessary. I don't need to say much about those. The asterisk let me just explain since it isn't on here.

MEMBER SHACK: Which slide are we looking at?

MR. LOBEL: I'm sorry.

MEMBER SIEBER: Sixty-three.

MR. LOBEL: This one.

MEMBER SHACK: Oh, the first one.

MR. LOBEL: Yes, the first one is BWRs. The second one is PWRs. But they're pretty much the same. The asterisk just means that for at-risk there are certain BWRs where the blowdown from the safety valves doesn't go to the suppression pool. It goes out into the containment. So there's a potential to generate some debris from that. But the limiting event for both the PWRs and the BWRs with respect to containment accident pressure is the LOCA.

CHAIRMAN WALLIS: And who big a LOCA?

MR. LOBEL: I'm sorry.

CHAIRMAN WALLIS: How big a LOCA? Small LOCAs presumably we don't do this if they're small enough.

MR. LOBEL: Well, in this one PWR calculation it was a small break LOCA that was limiting.

CHAIRMAN WALLIS: So it could be any size.

MR. LOBEL: And I don't understand why and I've asked them the question. The review is still going on and I haven't gotten an answer back yet. But I think the satisfying point of that is that they did do a break spectrum to find what the limiting case was and for the PWRs, LOCA is really the only event that gives you recirculation. There are some PWRs where you need recirculation for the steam line break if the containment sprays are on for a long time. But the LOCA is still the limiting event.

MEMBER SIEBER: Now the Barsebäck plant was one where safety relief valve discharges went to containment atmosphere.

MR. LOBEL: Right.

MEMBER SIEBER: That's why they got all the debris.

MR. LOBEL: Right. So I'm done unless there are any more questions.

MEMBER SIEBER: Okay.

MEMBER DENNING: I guess just some comments. I'm not sure whether this is the right time or later as far as summarizing what might be presented to the full committee or things in the interim period, but one of the things that concerns me which you addressed but I'm wondering if we could have more information on and that is it is possible, they are allowed in a regime in which there is cavitation occurring and you made arguments as to why even though there's cavitation that there probably isn't significant damage being done. I was wondering if you could provide more evidence of that, if there's more evidence we could see of that.

MR. LOBEL: I can provide you with, I have licensee events reports, vendor reports, licensee reports on the cases that I cited there and a few others that I'd be glad to provide. They're all publicly available and we can add the references to the transcription too.

MEMBER DENNING: That's fine. That sounds of interesting to me. The other things that we didn't really get into in detail and I'm not sure whether this is the right reg guide that relates to it, but it is clear that the properties of the fluid can be affected by debris and I'm not talking now about the pressure drops across the debris, but just this question of could you really be affecting the NPSH by just having added materials that could affect the NPSH and I think Graham asked that question. I don't think we really had an answer for it.

MR. LOBEL: Right. I don't know the answer offhand. There may be some experience that's available from people who operate pumps, paper mill pumps, slurry pumps and things like that. Of course, that may be too much debris in the water. But I can look into that some. I didn't try to find any information on that. I don't know the answer.

MR. ARCHITZEL: This is Ralph Architzel. Good morning. I wanted to jump in one point and ask a question which is on that point. I'm not going to contribute much other than to say that we worked at -- but not that aspect of it but --

CHAIRMAN WALLIS: We expect it from somebody.

MR. ARCHITZEL: That's what I wanted to mention it.

MR. LOBEL: I will take it as an action to see what I can find.

CHAIRMAN WALLIS: The other thing that

would help would be if you weren't just qualitive. If you could give examples of where you say here's a realistic calculation and when you do this conservatism you change things. I suspect that the conservatisms, particularly one or two of them, give you quite a lot of margin. I don't know until I see that.

MR. LOBEL: Another large one was the one that I didn't spend much time on but it was the number of pumps injecting into the vessel to begin with. That was worth a large amount --

CHAIRMAN WALLIS: You can talk about conservatism as much as you like but if these conservatisms only contribute say one or two percent to the final value, they may be less than the uncertainty in the value itself in which case you haven't really done anything very conservative. If your conservatism is a factor of four and the uncertainty is at 10 percent, then I can say that's very conservative. Until you put some numbers on these things, you haven't told me that.

MR. LOBEL: My boss said pretty much the same thing to me after we adjourned after the first session and I'm not going to promise anything but depending on money --

CHAIRMAN WALLIS: But if you deliver it, we'll ask you again.

MR. LOBEL: Maybe we'll try to get some technical assistance.

CHAIRMAN WALLIS: I think that would help me.

MR. LOBEL: And try and do a whole analysis ourselves where we can vary all these things and not just depend on what's in licensee submittals.

CHAIRMAN WALLIS: Maybe the reference plant might be induced to do some of these things too if they want to make a convincing case.

MR. LOBEL: Well, you'll be talking to them at some point.

CHAIRMAN WALLIS: We haven't talked to them. No.

MR. LOBEL: Oh, you haven't yet.

CHAIRMAN WALLIS: And it's been a great source of silence for awhile.

MR. LOBEL: Well, there's been a silence because the review isn't over yet. The SER hasn't been written yet.

MEMBER KRESS: Let me ask you. My impression so far is that in doing the conservatisms and the design basis analysis it looks like there's substantial conservatisms. We don't know how much, but it doesn't matter too much because anywhere between the positive suction air required and what you have you will probably get enough damage so that the pump is not operable and you will get increased flow anywhere in there, over the flow you got at the 0.5. So you don't really care where you are in this space because it's not going to matter with respect to performing the function. Is that the right impression?

MR. LOBEL: That's the right impression. That's honestly the impression that I have and I can't quantify it like I said. The other factor I think is important too that I mentioned before is it's not just the individual conservatisms, but it's the fact that you're saying that each of these conservatisms is occurring at exactly the same time with the same analysis. So everything that could go bad or be at its worst value is at its worst value on this one analysis.

CHAIRMAN WALLIS: I think what Dr. Kress was saying is if you forget about all the conservatisms it's still going to be okay.

MEMBER KRESS: No, that's not exactly what I'm saying.

CHAIRMAN WALLIS: You didn't quite say that.

MEMBER KRESS: I'm saying there was an implication in the previous presentation that said that you don't know where you are in that line between incipient and that positive suction that's required and it could be worse in there. But what I'm saying is no, it's not likely to be worse because you're going to get more flow if you're greater, if you have a greater net positive suction than you had in the required. You're going to have more flow than you do at the point --

CHAIRMAN WALLIS: It's worse from the point of view of where.

MEMBER KRESS: But the point of view of where is not bad enough that you're going to, for this small amount of operable time you need it, it's very unlikely that's it's not going to give you the flow that you need. This is the impression that I've gotten so far.

MR. LOBEL: I don't want to leave the impression too that we don't think this is important or that it's not an important effect. It's very important. Obviously, you're talking about the more important pumps in the plant during an accident. So

I don't want to give the impression that we don't think this is important. It's more that we're trying to put this in a perspective of what we know and --

CHAIRMAN WALLIS: These are important pumps if you ever get to the point where you're depressurized enough to use them.

VICE CHAIR RANSOM: I also wonder too if there aren't some instabilities in all of this where if you start to cavitate, for example, you reduce the head that's produced, that reduces the flow, that increases the temperature of the water which is being in dumped into the sump and that just further causes increasing cavitation. So you go to zero flow.

MR. LOBEL: You don't want to get to that stage.

VICE CHAIR RANSOM: Right. Is that a possibility?

MR. LOBEL: If things got bad enough, yeah.

MEMBER KRESS: Certainly if you went beyond this --

MR. LOBEL: And that's why too if we went to the statistical method, I think we'd want to go back and look at the margin question again. Because if we're going to be using a best estimate and uncertainty and saying we have so much uncertainty and we know where we are better, we would want to know where we are better with respect to the margin too.

VICE CHAIR RANSOM: Certainly this non-parametric statistical approach seems to be a very powerful way to go and I don't see too many people or the NRC moving in that direction very fast.

MR. LOBEL: It was something that just came up with this reassessment and we have talked to some people about it. But the industry needs an incentive to go in that direction and I don't know that there is one.

VICE CHAIR RANSOM: It would see like if they can achieve some benefits from it there could be large incentive.

MR. LOBEL: The incentive, the reason we suggested it, the incentive to us is, and I don't know if this has come across in what I've said, but the incentive is that we don't want to have disagreements with stakeholders about whether it's wise to take credit for containment pressure for NPSH if there really isn't a need to take credit for containment in the pressure. If we're doing things in a way that puts the NRC in a box where we're defending why it's okay to use over-pressure when it's really not necessary, that's not a good place to be and -

VICE CHAIR RANSOM: That's probably an easier way out. But on the other hand, the statistical methods too, it's not clear that you're only statistically taking credit for over-pressure. In other words, there may be a few cases where you would but for the majority not.

MR. LOBEL: That's the feeling. Yeah.

MEMBER SHACK: One more. The reg guide also focuses on the calculation of the available NPSH.

MR. LOBEL: Right.

MEMBER SHACK: We had these discussions that your required NPSH isn't necessarily NPSH-r. You're willing to go below that and that's not at all discussed in here. Is that handled?

MR. LOBEL: There is a position in there that says that you could take credit for pump cavitation if you do the testing and the inspections.

MEMBER SHACK: Okay. That's in there somewhere.

MR. LOBEL: Yes, it's in there somewhere. I can't quote exactly where it is.

MEMBER SHACK: I'll look for it. On the electronic copy, I can search.

MR. LOBEL: It's one of the positions

under BWR and PWR.

CHAIRMAN WALLIS: I have a request from probably the people from this morning. We got these Bingham Prop Curves that came to us as part of the evidence and some of the stuff is essentially illegible. Some of the more important things I can't read. It would be very good to have a copy I can read. Maybe it's in the reproduction here or somewhere else.

MR. CARUSO: Actually, that was all sent to me electronically. I'll give you the electronic version.

CHAIRMAN WALLIS: Is it clearer?

MR. LOBEL: Yes, those are from Reference -- and I have a version 2 that they're hard to see but maybe not that hard to read. I could show Ralph what I have and if there are better --

CHAIRMAN WALLIS: I think what they're showing is how the pumps perform under these degraded conditions when you have an NPSH which is less than required and then you have this three percent and six percent and so on.

MR. LOBEL: When you do that pump testing, you measure the head and flow and then you also measure required NPSH typically at the three percent.

But in this case, they did other tests also.

CHAIRMAN WALLIS: Right. They went beyond that.

MR. LOBEL: Yeah. So those are from the vendor. It's not anything we have.

CHAIRMAN WALLIS: Now these are from the pumps that are actually installed in this reference plant.

MR. LOBEL: Right.

CHAIRMAN WALLIS: Yes, they are. It says so.

MR. LOBEL: Yeah, they're reference plant pumps.

CHAIRMAN WALLIS: So when you do your reviews, do you look at curves like this in order to decide if a situation is okay?

MR. LOBEL: In this case, we did because they're crediting pressure --

CHAIRMAN WALLIS: So you can identify operating points on these diagrams and all that and say this is okay because the flow is bigger than they need at these conditions or something.

MR. LOBEL: What I did was look at what was assumed in the analysis and then look at those curves and see whether they are consistent and reasonable and are conservative.

MR. CARUSO: Graham, I have a better copy here. Bill Sherman has given me one.

CHAIRMAN WALLIS: Okay. Thank you.

MEMBER SIEBER: Do we have time for a break?

CHAIRMAN WALLIS: Time for a break. Well, what do we have to do now? We have to hear about risk. Is that it?

MR. LOBEL: Yes.

MEMBER SHACK: We're running late.

CHAIRMAN WALLIS: Are we running late or early? I can't --

MR. CARUSO: Actually, you're not running very late because you have one comment from Mr. Shadus. He won't take very long and then we have time for discussion.

CHAIRMAN WALLIS: I don't think we're late at all, are we?

MR. CARUSO: I don't think we're late at all.

VICE CHAIR RANSOM: Okay. These are two that were passed. So why don't we take a break until three? Why don't we take a break until 3:05 p.m.

CHAIRMAN WALLIS: 3:05 p.m. okay.

VICE CHAIR RANSOM: By the correct time, I think 3:00 p.m. Off the record.

(Whereupon, the foregoing matter went off the record at 2:47 p.m. and went back on the record at 3:07 p.m.)

VICE CHAIRMAN RANSOM:: Maybe we better get started. We're going to hear about PRAs, I guess.

MR. STUTZKE: Just to remind you, I'm Marty Stutzke from the Probabalistic Safety Assessment Branch in NRR, and I'm here today to talk to you about some risk insights concerning loss of positive suction head and how it relates to containment over-pressure.

It's been kind of an interesting odyssey of going through the literature to find out how this has been treated in the past. You might notice on my first slide, I'm going all the way back to the WASH-1400, the original reactor safety study.

MEMBER KRESS: Is this in the NUREG --

MR. STUTZKE: Yes, it is, a little bit. But I went all the way back there. Perhaps the joke is I had all these books on my desk of WASH-1400, and the people that I work with come by and say why are you reading this? WASH-1400 was published one year before I graduated at Tennessee, 1974. In fact, it was a text of mine when I was in school.

MEMBER KRESS: I'm glad to hear you went to Tennessee.

MR. STUTZKE: I had to work that in some how.

MEMBER KRESS: You know, you just raised yourself in my view.

MEMBER SHACK: It's not going to help you.

CHAIRMAN WALLIS: We've got an interpreter on the ACRS, too.

MEMBER KRESS: He doesn't speak Tennessee. I don't know. He didn't come from there, he just went to school there.

MR. STUTZKE: I've been educated.

MEMBER KRESS: Yes.

MR. STUTZKE: So the answer is I just don't read from the Book of Revelation, I read from the Book of Genesis, sometimes. So I had to go all the way back to WASH-1400. I've looked at some of the IPEs summarized in NUREG 1560, which is the EPI Perspective Document put together by the Office of Research. Then I looked at very recent guidance from the ASME PRA Standard and the RASP Handbook, which is instructions on how to draw SPAR models like that.

When you go back to WASH-1400, sure enough the BWR event tree talked about containment leakage following LOCA. It's an event right in the event tree header. And the notion was this; if you had leakage greater than about 100 percent per day, then you had no long-term cooling, then the ECCS pumps would cavitate, and that led you directly to core damage.

The concern here was a balance. If the leakage was too big, you didn't have enough pressure, and therefore the pumps cavitated. On the other hand, if the leakage was too small, you would over-pressurize the containment and that would subsequently fail, and all the inventory would leak out, and that would also lead you to core damage, so you had -- the notion was you had to have just the right amount of leakage in the containment. Of course, at this time, the idea of hardened containment vents hadn't been created yet, so they were interested in this.

It goes on in that study to say 100 percent leakage per day is equivalent to a one inch hole in the containment, which I thought was kind of interesting, how small a hole it takes.

CHAIRMAN WALLIS: One hundred percent leakage kind of is contrary to the whole purpose of the containment though, isn't it?

MR. STUTZKE: That's right.

CHAIRMAN WALLIS: Leaking everything

that's in there.

MR. STUTZKE: Well, if Rich heard 100 percent, he'd probably be taken to the hospital or something.

VICE CHAIRMAN RANSOM:: Well, one thing peculiar about this, though, is even if you had 100 percent leakage, you would still have one atmosphere pressure basically inside the containment which for most cases was adequate NPSH.

MR. STUTZKE: That's right.

VICE CHAIRMAN RANSOM:: So is that an inconsistency in the --

MR. STUTZKE: It may well have been a mistake in the study. So they estimated some failure probabilities of having this size leakage, two times ten to the minus 5 for small break LOCAs, five E minus three for large LOCAs into the drywell, leakage out of the drywell like this, and they were worried about over-pressurizing some pipes, interfacing LOCAs for the wetwell three times ten to the minus four.

CHAIRMAN WALLIS: One inch equivalent diameter wouldn't be absurd in a main steam isolation valve that didn't close properly.

MR. STUTZKE: Yes. Well, easily detectible in my experience.

MEMBER SHACK: Now what do these failure probabilities mean?

MR. STUTZKE: The probability that you have leakage greater than 100 percent per day.

MEMBER KRESS: This is a conditional probability given these LOCA --

MR. STUTZKE: Given a LOCA, given these break sizes of LOCAs.

MEMBER DENNING: I think they were pre-existing, weren't they?

MR. STUTZKE: It's a mixture of pre-existing faults, as well as some what we'll call dynamic that depend on the break size.

MEMBER DENNING: My memory -- I actually do remember back then, and I wasn't in school at the time, but there were some cases of plants that had operated for years with unisolated and not knowing it. Now, of course, this is a BWR here, which, of course, is quite different, and they were -- so my memory was that we gave very small probability to the BWR because of the nitrogen inerting in them.

MR. STUTZKE: Right.

MEMBER DENNING: I think we have larger to PWR.

MR. STUTZKE: So I view this, this was

interesting to see the loss of NPSH had been considered in PRAs from the beginning, and it gives you some feeling for probabilities, how likely people thought it was at that time. But let's put the past aside, and go on a little bit more.

Next slide entitled, "Loss of DHR". This comes from NUREG 1560, which are IPE Perspectives the Office of Research had compiled and compared, and contrasted various IPE results. And in the summarization of those, they defined a category called "Loss of Decay Heat Removal in BWRs." That includes things like failure of the suppression pool cooling system and cavitation of the pumps due to loss of NPSH. So the whole frequency here of loss of DHR is a mix. We're only interested in some piece out of this frequency, but I don't know how much that piece is, because it wasn't broken out here.

I can give you an idea, if you look the contribution somewhere between 5-75 percent for the category BWR 1-2-3, you need to read the report because they tried to group plants together that had similar physical characteristics, system designs, things like this. You'll notice some of the BWR-3s crept over into the other category, but the report is very specific. These plants belong to these categories, and you can read that.

Just so you know, the plant-to-plant variability on the loss of DHR contribution spans two orders of magnitude. Now that's not the actual uncertainty distribution. That's just the variability among the different results that was observed like this. And so you can see in some cases BWR mark one containments, the contribution was very small, 5 percent, in other cases was dominant. We don't use the word "dominant" any more, we have significant results, not dominant results.

MEMBER SHACK: Explain to me where the two orders of magnitude comes from again.

MR. STUTZKE: That's just the spread of the contribution from loss of DHR. For example --

MEMBER SHACK: So I'm looking at a mean value here, a median?

MR. STUTZKE: You're looking at an average of the point estimates. I wouldn't even call them point estimates. You're looking at an average of the central estimates, because some IPEs gave you mean, some gave you medians. It's whatever they claim that the number was.

CHAIRMAN WALLIS: This is one of the peculiarities of PRA, that you have what look like some of the plants, and yet there's a two order of magnitude spread and contribution is something which is sometimes very important. It seems a little odd, doesn't it?

MR. STUTZKE: That's why we have initiatives on PRA quality.

MEMBER DENNING: Sometimes it's not the PRA, though. Sometimes there are significant differences in plants.

CHAIRMAN WALLIS: Physical differences or something.

MEMBER DENNING: The sanity with which we develop --

MR. STUTZKE: It is frustrating. You can take the same plant analyzed by two PRA teams and get different results and different conclusions. That's possible.

CHAIRMAN WALLIS: That's a concern, too. It's the same plant we're talking about.

MR. STUTZKE: Such is the state-of-the-art. Okay. But that's a good segue into my next slide on PRA modeling guidance. Now we have the ASME PRA Standard, which has been endorsed with appropriate clarifications and qualifications, and REG Guide 1.200. And when you read that, you find three supporting requirements that address treatment of net positive suction head in PRA models, and I've listed them there. So it's clear to me that current modern PRA guidance is adequate to ensure that PRAs treat the effect.

Again, use of the standard is not mandatory. Nobody is required to actually have a PRA. It's not part of the licensing basis, whatever like that, but if they choose to follow the standard, then it's well addressed inside the standard. The Staff's own guidance, the RASP Handbook, which is kind of a how-to handbook of methods and best practices things for building SPAR models, also talks about the need to model loss of NPSH in these things.

So what did I learn from this odyssey, this walk down memory lane? First of all, you can conclude that for BWRs, the loss of NPSH has been addressed. There's a statement in NUREG 1560 that says it's unimportant for PWRs because of the design of the ECCS pumps. It's not explicit in there what is meant. It's my understanding they mean the pumps are capable of handling saturated liquid, so there's not a cavitation concern like this.

When you delve into the modeling details, when they talk about loss of NPSH being modeled in

PRAs, the emphasis is on containment venting, not containment over-pressure credit. Now let's remember the sequence of interest here.

We have a large break LOCA, emergency core cooling system is working, the heat from the core is going into the suppression pool which causes it to heat up. The suppression pool cooling system should operate, but we'll presume that it fails, so now the containment is slowly going to pressurize. And the problem, in order to prevent that, is to use a hardened containment vent to depressurize the containment. And if you look under that fault tree model, you'll find a human error, an operation action event that says, "The operator fails to initiate containment venting, or fails to control containment venting causing loss of net positive suction head." Okay.

CHAIRMAN WALLIS: That sort of assumes that the containment is a necessary part of the NPSH calculation.

MR. STUTZKE: That's correct.

CHAIRMAN WALLIS: You need to take credit for it.

MR. STUTZKE: My third bullet here is, so far, I have not identified a single PRA that considers or models the loss of net positive suction head due to failure of the containment over-pressure. Okay.

The first step in operator error related to the containment venting function. What we're interested in is suppose there's a pre-existing failure or flaw inside the containment, so that the over-pressure is not there when we need it. Perhaps the containment isolation system fails, maybe there's just a hole, somebody left the door open, all of these sorts of things. And I have not been able to identify a single PRA that treats that. And that includes the Staff's SPAR models, as well. I confirmed that one with the Office of Research.

CHAIRMAN WALLIS: So in the second bullet what happens is the containment is pressurized, and it's been pressurized so much that the operator vents it, and then maybe the operator leaves the vent open.

MR. STUTZKE: Right.

CHAIRMAN WALLIS: At some subsequent time the pressure gets too low in the containment?

MR. STUTZKE: Right. Then it cavitates the pumps.

CHAIRMAN WALLIS: And there could have been no core damage until this cavitating of the pumps.

MR. STUTZKE: That's right. It's important to understand it's the loss of containment integrity happens --

CHAIRMAN WALLIS: First.

MR. STUTZKE: First.

CHAIRMAN WALLIS: Right.

MR. STUTZKE: That's what's inducing the core damage. That's the dependency that Mr. Sherman was talking about this morning.

CHAIRMAN WALLIS: Right. Right.

MR. STUTZKE: That's precisely the --

CHAIRMAN WALLIS: An unusual sequence of events, where the containment failure causes the fuel to fail.

MR. STUTZKE: Well, it's not unknown in PRAs to model the sorts of sequences like that.

MEMBER DENNING: Well, you certainly could have in this case here if you open the vent and get a real blow-down of the containment, you could have massive boiling in the suppression pool. I mean, that would be --

MR. STUTZKE: Right. Flash the water.

CHAIRMAN WALLIS: Well, if it's boiling in the suppression pool, it's likely to be boiling in the pump, isn't it?

MEMBER DENNING: Exactly.

MR. LOBEL: Well, let me just say that the temperatures that they predict for these kinds of events in the suppression pool are usually below 212. The highest I've seen was 205, and most of them were down around --

CHAIRMAN WALLIS: So you wouldn't boil the suppression pool.

MEMBER DENNING: No. I think in PRA space here, where you have loss of suppression pool cooling. So you're getting --

(Simultaneous speech.)

MEMBER DENNING: -- where you're threatening the failure of the containment, so you vent it.

CHAIRMAN WALLIS: Okay. That's a much more severe case than licensing basis.

MR. STUTZKE: Oh, yes, very severe. To date, there have been no license amendment requests for crediting containment over-pressure that were risk-informed. None of them have been risk-informed, so I was not able to find any PRA information from these to tell me -- to give me any sort of insight at all like this.

MEMBER SHACK: What other scenarios would lead to that loss of containment over-pressure?

MR. STUTZKE: Well, let me talk about that. To talk about that, I wanted to remind everybody, a PRA model is a mixture of event trees and fault trees. Event trees describe sequences, fault trees describe how functions or events in the event tree fail. It's difficult to pick on a single fault tree and gain a grasp of what's going on in the PRA. You need to understand how it's all linked together. There are various modeling techniques. Most people use what's called a small event tree, small number of events, and large fault trees. Some people use large event trees, and small fault trees. The current trend seems to be to use large event trees and large fault trees. But the modeling methods are based on -- they were derived out of the limitations of our computational ability to solve large fault trees and large event trees. That's how these things get there.

But the point is, it's very difficult just to dive right into a model and say that's the event in the fault tree that's wrong. You need to look at the whole context of the sequence, and that determines how human errors are determined, that determines the boundary and initial conditions for some of the failure events.

CHAIRMAN WALLIS: You have these trees I've seen this morning that flow forward, where somebody leaves the vent open and this causes the pump to cavitate, which causes the fuel to get into some awkward condition, where it's relating reactivity. Then the operator closes the vent. This business of looping around where you now cancel something and it goes back and affects things again in the PRA, I'm not sure how you do that. PRAs always seem to be going forward in a directional --

MR. STUTZKE: We don't go backwards too well. There's nothing inherent in the event tree/fault tree structure that imposes a sequential timing.

CHAIRMAN WALLIS: Well, you change the situation, you correct the error and it goes back.

MR. STUTZKE: That's right. Traditionally, we assume we go forward, and then if we produce the results of a PRA, we'll do what's called a recovery analysis and say well, suppose he detects his mistake and he takes some action. And we'll add that probability on case-by-case situation.

CHAIRMAN WALLIS: You go right back to the new situation again, because you're always going forward with it.

MR. STUTZKE: That's right. It's the nature of the beast, so to speak.

MEMBER DENNING: There are dynamic techniques that haven't really particularly caught on, but there are -- I mean, there's a rigidity to event tree and fault trees, the way they're done, other than you have this recovery that you can do if you --

MR. STUTZKE: That's right.

MEMBER DENNING: But there are dynamic techniques that are under development, that I don't think --

MR. STUTZKE: The other thing to realize is that the failure events, the fault events inside a PRA logic model are brewing, and they're either yes or no. It either occurs or it doesn't, so when we say a pump fails, we are picking somewhere in the spectrum of flow rates and say the flow rate is at this point, and that's so low that we can't tolerate it.

CHAIRMAN WALLIS: With all these pressures and temperatures going up and down, you could have the pump cavitating and not cavitating, cavitating, not cavitating. It wouldn't really fail.

MR. STUTZKE: That's right.

CHAIRMAN WALLIS: They might operate, and not operate, might operate partially and all that.

PRAs don't deal with that.

MEMBER SIEBER: The PRA says it failed.

MR. STUTZKE: The PRA will say that it's failed. In other words, a typical success criteria may be you need one out of two low pressure injection pumps to work. We don't have success criteria that says both pumps are working at 50 percent of their rate of flow. We can't handle that very well, or one is working at 75 percent and the other at 25 percent. It's either working or it's not working.

MEMBER KRESS: You could add up those probabilities and put those on your --

MR. STUTZKE: That's true.

MEMBER KRESS: It can't be done easily. I think sometimes it's done.

MR. STUTZKE: There's been efforts, but it's not caught on to my knowledge.

CHAIRMAN WALLIS: So it is a way of avoiding having to do all the thermohydraulic calculations all the time, and have sort of a -- you'd actually model the entire sequence and what's going on everywhere. You'd do it much quicker by having probabilities.

MR. STUTZKE: Right.

CHAIRMAN WALLIS: You lose something when you do that.

MR. STUTZKE: I have to congratulate you. You guys are just leading me to the next slide. It's wonderful. Here was my dilemma. The Staff, Management, you guys wanted to know what can risk assessment say about credit for containment over-pressure, and here I'm dumbfounded. I can't find a single PRA that even addresses it. So what do I do? What that means is Marty has to become a PRA analyst again, which I had done before I came to work for the staff. And in order to start PRA analysis, you need to begin to define what sequences you're worried about here, so the scenario is something like this.

Suppose that I need over-pressure. What does that really mean? What it means is the pump won't pump saturated liquid. The temperature of the fluid going to the pump, that atmospheric pressure gets high enough, that pump will cavitate, so I have two choices to prevent that. One is, I apply over-pressure on the pump so that I can suppress the boiling. The other way is I can cool the water. So the scenario that I need is a case where --

CHAIRMAN WALLIS: Unthrottle the pump.

MR. STUTZKE: Well, I can think about that. We tend to look in PRAs of bounding scenarios, so I hypothesized a case where we have a LOCA occurring like this, and we have no containment pressure whatsoever, think of the door is open for some unknown reason like this. What would happen to that pump then? And the intuition said well, nothing right now because the water is cold. It takes some time for all that energy to come out of the core and heat that water up. How much time? That's crucial for the operator action. If it's a matter of minutes, we'd probably have difficulty because you won't get the system started in time. It won't react in time. If he has days, why am I even concerned? So the question is, how much time does the operator have to get that water cooled off inside the suppression pool?

So I attacked the problem by doing a freshman-level thermohydraulic calculation. All right. I got a Torus. I got a bucket of water here. It's at this temperature.

CHAIRMAN WALLIS: And you're adding so much --

MR. STUTZKE: I need to add so much energy to it. How much energy do I need? I can integrate the decay heat curve, and I came up with four hours. Okay? So that's telling me, well, it's not five minutes, and it's not three days. It's some time.

It's four hours.

CHAIRMAN WALLIS: You're putting all the energy into the suppression pool.

MR. STUTZKE: Right.

CHAIRMAN WALLIS: You're putting all the energy in, or you're not doing steam go out to --

MR. STUTZKE: All of the constant mass plus the water.

CHAIRMAN WALLIS: But, in fact, there's steam going out through the leaky containment.

VICE CHAIRMAN RANSOM:: Now is that four hours to the point of pump cavitation?

MR. STUTZKE: To the point of pump cavitation. And the way that's done is by assuming the net positive suction head required equals the net positive suction head actual. I know all the friction losses in the system. I know the elevational head. Eventually I can back-calculate what the vapor pressure needs to be, and then I can look up on the steam tables what the temperature of the water is.

CHAIRMAN WALLIS: Probably half the enthalpy is going out in steam, so it takes eight hours instead of four.

MR. STUTZKE: So you caught me, and I admit, I am not a thermohydraulic --

CHAIRMAN WALLIS: I didn't try to catch you. I'm just trying to --

MR. STUTZKE: Well --

MEMBER KRESS: No. Most of that enthalpy goes into the pool.

MEMBER SHACK: PR guide guys are allowed to use conservative assumptions.

CHAIRMAN WALLIS: It's conservative. He's got at least four hours. He might have eight or twelve if you're more realistic.

MR. STUTZKE: It wasn't until the mid-1990s that I actually did thermohydraulic calculations to do PRA success criteria. We used to get them by reading FSARs and doing back-of-the-envelope calculations, and these sorts of things. But anticipating your discomfort with this, we asked the licensee of the reference plant to make a real calculation, so they made MAAP calculations for me, and that's shown on the next page.

CHAIRMAN WALLIS: It's time we looked at MAAP again to see if it's a good code.

MEMBER KRESS: Well, for this, it's probably okay.

MR. STUTZKE: This is a pretty straightforward calculation like this, but it does have some of the heat sinks and things. Again, no credit at all for containment pressure, over-pressure. We did not start suppression pool cooling at time zero, and the idea was how long until we cavitated, and the result said four hours. So either we have a common cause failure that MAAP this no matter than Marty's freshman-level engineering calculation, or we have an agreement here.

So let's presume that the operator has about four hours to get his suppression pool cooling up and running, so we can begin to form --

CHAIRMAN WALLIS: HEP is a Human Error --

MR. STUTZKE: Human Error Probability.

CHAIRMAN WALLIS: Only going to do it four post, at ten post he's going to make a mistake?

MR. STUTZKE: That's the number. The way of doing the HRA is this, you need to worry about diagnosis problem. Does the operator realize there's a LOCA happening like this, and then there's an implementation part to human error. How long does it take him to actually light off the system once he decides he needs to do this?

Implementation error seems to be impossible in less than one minute. We talked to some shift supervisors. It's a very straightforward task.

It's done in the control room, and not running throughout the plant to open valves and things, like I had to do when I was in the Navy. It's well-proceduralized. It's well-trained upon. It's simulated. This is a very straightforward sort of action like this, so virtually all the four hours is available for them to think about it and realize gee, maybe we ought to light off suppression pool cooling.

So I went and used the technique for Human Error Rate Prediction, NUREG CR-1278. That's one of the very early Human Reliability Analysis authoritative documents. There are different curves, and I'm perhaps glad that George Apostolakis is not here because we wouldn't get beyond this point, about what's the appropriate curve like this. I used this because it's well-accepted. It's accepted by the ASME Standard and whatever. And what it says is that the median probability that he fails to diagnosis this is four times ten to the minus three over four hours.

Now again, that's not just an operator. That's the operating staff, which would include the shift supervisor, probably management by this time has heard something is going on, the NRC is involved like this, so this is not an unreasonable number for this length of time.

Realize that a lot of the Human Reliability that we deal with in PRA, and especially on BWRs concerns very short time frames. The operator response in a BWR following ATWIS is on the order of 30 seconds or a minute.

CHAIRMAN WALLIS: We learned at TMI, if he misdiagnoses the situation, he can do the wrong thing for many hours.

MR. STUTZKE: That's right, days. But that's what the number tells me. We'll talk about the sensitivity to that type of number. So the next thing we need in our PRA calculation is what's the likelihood of loss of containment integrity to the point where the containment is not pressurized at all? And I went into the reference plant's IPE, I used the same fault tree that you guys used, and I requantified it. I put new numbers in, I looked for mistakes, I cleaned it up and I generated a number of six times ten to the minus three.

CHAIRMAN WALLIS: When you multiply all these together, you're going to get something impressive.

MR. STUTZKE: Oh, yes.

CHAIRMAN WALLIS: That's the next page.

MR. STUTZKE: That's the next page. So

you pull up your paper at large LOCA frequency, and we could argue about that until the cows come home.

CHAIRMAN WALLIS: Everyone does this and they say I don't believe any numbers that are smaller than a billion.

MR. STUTZKE: Yeah. Anyway, you multiply these things together, so let's go through the calculation from left to the right. Three times ten to the minus five per year is the LOCA break frequency. Six-E minus three is the probability of loss of containment integrity. Four-E minus three is the probability that the operator fails to light off suppression pool cooling in four hours, and he generates a number that's very small. It's certainly below one-E minus six. And according to Reg Guide 1.174, that's classified as a very small risk increase.

MEMBER DENNING: I missed something. In the earlier discussions we had on the design-basis accident, there's no credit taken for suppression pool cooling?

MR. STUTZKE: No. They credit that.

MEMBER DENNING: Well, why is that then required to lead to core damage here?

MR. STUTZKE: Because if I have a loss of containment integrity, and suppression pool cooling fails, I no longer have the option of containment venting to remove the heat. I've cavitated. I've cavitated at this point. So this is adding a new sequence into the PRA is what I'm trying to get at.

MEMBER DENNING: Well, isn't the sequence involving a large break LOCA with the open door like our analyses, isn't that core damage?

MR. STUTZKE: Not directly. That's what I'm trying to say, is it doesn't happen instantaneously. It takes at least four hours to heat the water up. It takes time.

CHAIRMAN WALLIS: That time doesn't make us very happy.

MEMBER DENNING: I'm still not sure what you're saying is -- in the normal analysis of the large break LOCA you start the suppression pool cooling. Is that true?

MR. STUTZKE: That's correct.

MEMBER DENNING: And in the analysis that we saw, you could, if you didn't have credit for over-pressure, you would cavitate.

MR. STUTZKE: That's right.

MEMBER DENNING: Now what are you doing that saves the day relative to that? I mean, why --

MR. STUTZKE: Okay. In the normal --

MEMBER DENNING: I assume you'd be worse off if you don't have suppression cooling --

MR. STUTZKE: Right. In the normal scenario, the scenario progresses as follows. I have a large LOCA. I have the integrity of the containment, but I fail suppression pool cooling, and I recover the core by going on and containment venting. That's the traditional BWR sequence. So what I'm adding here is suppose I've lost containment integrity to this, I can't vent, but I can still run the suppression pool cooling if I get started in time with an open containment. As long as the water stays cold enough, and I think it's about 175, the pump won't cavitate.

MEMBER DENNING: I'm still confused. Let me walk through it again and see if you can straighten me out.

MR. STUTZKE: Go ahead. It took me a week to figure this out.

MEMBER DENNING: Okay. Again, it looked to me like -- I mean, in my earlier discussion, in the normal design-basis accident where we take credit for suppression pool cooling, if you lost your containment over-pressure, you would cavitate.

MR. STUTZKE: That's right, because of the conservatisms placed in that calculation.

MEMBER DENNING: Yes.

MR. STUTZKE: Whereas, our's is a realistic.

MEMBER DENNING: You're thinking this is a realistic --

MR. STUTZKE: This is realistic. We removed all the decay power conservatisms.

MEMBER DENNING: So you've taken away conservatisms.

MR. STUTZKE: Right. It's an effort to quantify what actually happens without the conservatism.

MEMBER DENNING: And what your analysis tells you realistically is that your suppression pool temperature never gets high enough that you need the containment --

MR. STUTZKE: If they start it in four hours. In fact, part of the MAAP runs --

MEMBER KRESS: This kind of tells you in risk space that it's not very important to maintain containment over-pressure?

MR. STUTZKE: That's right.

MEMBER KRESS: In risk space.

MR. STUTZKE: In risk space, yes.

MEMBER KRESS: But in defense-in-depth space, because we haven't done any uncertainties here, and don't know what the uncertainties are in these numbers, it might be a good idea to do it anyway.

MR. STUTZKE: Well, let's talk about that, because that's the next slide.

MEMBER DENNING: Well, there's one other, and this I think is important, and that is that you're saying in best estimate space you don't need it.

MR. STUTZKE: That's right. That's right.

MEMBER DENNING: And so you have to have some other failure to get you to core damage.

MR. STUTZKE: That's right.

MEMBER DENNING: And not surprisingly, particularly if you can find it with a large LOCA.

VICE CHAIRMAN RANSOM:: On best estimate space, if you don't lose the containment, you don't damage the core either. Right? So that one is a no-nevermind. And what you've shown is if you lose the containment, it's still a no-nevermind, a very small increase in risk.

MR. STUTZKE: It's a very small increase, because of the time, and there's a lot of water in a suppression pool. It takes a while. Personally, I was surprised it took that long to heat it up.

MEMBER KRESS: That's a lot of water.

MR. STUTZKE: It's a lot of water.

MEMBER KRESS: You just integrated the decay heat curve to the point --

MR. STUTZKE: Yeah, I actually took it out of an old textbook, the old El Wakil heat transfer textbook.

MEMBER KRESS: That's good.

VICE CHAIRMAN RANSOM:: Or verified it with MAAP. Right?

MR. STUTZKE: And then we verified it with MAAP. Let's talk a minute about the defense-in-depth aspects. As the segue into this, I would remind you Reg Guide 1.174 of the Standard Review Plan, Chapter 19 all contain five key principles of risk-informed decision-making. And one of the principles says, "Any increase in risk is small and in keeping with the Commission's safety goal policy." Another principle says, "Defense-in-depth is preserved." There are three other ones, but not relevant to this discussion, I think.

How do we decide the defense-in-depth? We go to the Standard Review Plan, Chapter 19, and it contains four questions to help us decide, and that's what I've tried to show you on the next slide like this. The first question says it's the change. When they talk about change, they're talking about "the impact of the license amendment request does not result in a significant increase in the existing challenges to the integrity of the barriers." Increase in the existing challenges means initiating event, so creating new initiating events is something unusual - well, no. All we've done is taken credit for pressure. We're not adding hardware to the plant, we're not changing the plant design like this.

The next question, "The proposed change does not significantly change the failure probability of any individual barrier." Now you have to read the language here. It doesn't say it does not change it, it does not significantly change it. Changes are allowed, as long as they are not significant. So we indicate, first of all, this is where the three barrier concept comes in - again, the fuel cladding itself, the reactor coolant system, the containment itself like this. We know from the fact that there's a very small change in core damage frequency, which was the calculation of a couple of sheets ago, that there's a very small change in the failure probability of the fuel like this.

We haven't actually, by granting over-pressure credit, changed the failure probability of the reactor coolant system. All right. That's whatever the LOCA frequency is for whatever mechanisms. Similarly, because we have not actually physically changed the containment, we haven't changed the probability that the containment fails, just by granting credit for over-pressure. So what we're talking about with respect to this question is the first barrier, the fuel barrier, the core damage frequency, and the change is small.

The third question, and this is the hard one. This may be the heart of the problem - "Proposal does not introduce new or additional failure dependencies among barrier that significantly increase the likelihood of failure." Again, notice the word "significantly." In fact, when we credit containment over-pressure, we've introduced a dependency between the fuel clad and the containment. All right. There's no question about that. If the containment fails during a large LOCA in the design-basis, we may melt down the -- we may damage the fuel. Okay. So the question is, how strong is that dependency? How significant is that dependency? And again, the previous examples shows change in core damage frequency is very small. It's insignificant. It's not a significant increase.

One thing I should add to this is, realizing in these scenarios the change in core damage frequency is equal to the change in large early release frequency, because the containment is faulted, is failed now. Okay. So if, in fact, you get into this scenario that I described before of LOCA occurs, the containment integrity is lost, and the operator fails to start suppression pool cooling, not only will you damage the fuel, but you'll have a release. There's no question about that, but the likelihood seems rather small.

MEMBER DENNING: You should just be measuring against the LERF criterion, rather than the CDF criterion.

MR. STUTZKE: Well, in fact, to compare them against Regulatory Guide 1.174, you have to do both.

MEMBER DENNING: Yes.

MR. STUTZKE: Yes, you've got to do both, but the LERF driver may well be the significant one here. So the last question is, "The overall redundancy or diversity among the barriers is sufficient to ensure compatibility with the risk acceptance guidelines." Yes, we meet the Reg Guide 1.174 guidelines.

MEMBER DENNING: Can I say that I think this is interesting, but I don't think you actually looked at the right risk question. I think the scenario that you really should have looked at, and it's difficult, is just the case that looks like the design-basis accident without this compounded failure of loss of suppression pool cooling, but taking into account the uncertainties in the phenomenology of the accident scenario, and doing a spectrum of realistic accident scenarios and see what's the probability when you include those phenomenological uncertainties, what's the probability that you really will have cavitation and core damage, without compounding it with the loss of suppression pool cooling. And that's a difficult analysis to do, and I'm sure that that conditional probability is small based upon what we believe the magnitude of these conservatisms are. But I think that was the real question to be addressed, not the one compounded by another event, which in this case you chose the failure of suppression pool cooling, but then assumed that your best estimate analysis was correct for the accident phenomenology.

MR. STUTZKE: This is not the same as the statistical treatment that Richard talked about before.

MEMBER DENNING: Yeah. I think it's really that. If you did that full statistical treatment and see well, what's the probability - I think that's really the question.

MR. STUTZKE: Right. Well, it's true because the credit for containment over-pressure is a design-basis consideration. It's not really a risk argument. We're dealing beyond the design-basis.

MEMBER SHACK: Well, I mean, I think you have to do both. I mean, this is one way to violate it, that's another. And you're arguing that intuitively you think the other one is the bigger contributor.

MEMBER DENNING: Well, I think it's the one that really addresses the design-basis space, and what -- and the concerns that we heard this morning.

MR. STUTZKE: Yes, I don't disagree with you. It would be interesting to see the results of the calculation.

MEMBER KRESS: But it's irrelevant to a risk.

MR. STUTZKE: But it's irrelevant to the

risk that --

MEMBER DENNING: No, I don't think so. Both of them are, perhaps, relevant to risk. I mean, maybe there are a whole variety of other compounding things that could lead to failure that would be impacted by the failure to isolate.

MEMBER KRESS: I think he has to do what he did for the whole spectrum of LOCAs, but what he did was chose one LOCA that's probably going to contribute the most to the risk and found out that that one is extremely small. And in risk space, I think he's covered. I don't think there's other sequences he needs to add into his thing. And then we can say well, what about design-basis space, that's what we're actually dealing with. That's a different issue.

MEMBER DENNING: Well, it's arguable as to whether you're in design-basis space when you compound a large break LOCA with an unisolated containment.

MEMBER KRESS: I mean, design-basis space, you're in some sort of stylized never-never-land. It doesn't have much to do with PRA and real space. It has something to do with it in the sense that it renders your system design to a state that it can deal with real space, which is PRA. But I think he covered the risk aspects. Now if you want to go back and say well, have we done a proper design-basis space analysis, and have we been able to quantify what the real margins are, you don't need to do what he says, the other thing.

MEMBER DENNING: What I was saying, Tom, is there is some risk that occurs when you just have loss of coolant accident and your containment fails to isolate. There's some probability of core damage associated with that. That's one risk-base scenario. He looked at another risk-base scenario in which he looked at loss of coolant accident, failure to isolate, plus loss of suppression pool cooling. That's another scenario that has some risk. But I think that it's probably more consistent with the concerns that have been raised, is how -- and when you ask how adequate is the conservatism in all of these compoundings of conservatisms, what we're really addressing is that risk of with a loss of coolant accident, and just failure to isolate, what's the risk? Not compounded by another thing, but just that. And there is some risk of core damage just based upon that, without compounding it with another failure of the loss of suppression pool cooling. And

I think that's what we're trying to get a feeling for, is how conservative are these conservatisms. If they're not very conservative, then that risk of just that event of loss of coolant accident and failure to isolate may be too high for us to accept. I think that's the question. These conservatisms we've talked about, are they enough that they prevent the scenario that I just talked about. And the only way you can really address it is doing the multiple scenarios, taking into account uncertainties, and see how big that risk space is.

MEMBER KRESS: I maintain that's already covered in the PRA.

MEMBER SHACK: Well, no. It's an uncertainty analysis of your math calculation for success. He hasn't done that. He's done a point estimate --

MEMBER KRESS: But assuming your success criteria is correct, it's already covered in the PRA, is what I'm saying.

MR. STUTZKE: The issue is, is the success criteria correct.

MEMBER KRESS: Yeah. That's --

MR. STUTZKE: That's what you're really asking, I think.

MEMBER SHACK: Yes. That needs to be addressed.

MEMBER KRESS: Yes, but it's not that it's not covered in the PRA, because it's in there. It all depends on your view of whether that success criteria has got a lot of conservatism in it.

MR. STUTZKE: I'm done.

CHAIRMAN WALLIS: So your conclusion is that there isn't a problem, is it?

MR. STUTZKE: No. I guess I'm not done. All right. Let's talk a little bit about where we should go maybe in the use of risk calculations and risk insights to try to grapple with this problem a little bit. I would certainly agree with you guys, it would be very, very helpful to do the whole Monte Carlo runs and see how close we really are, how much conservative out of Rich, what he's really done like that.

The other thing I'll point out is that what you saw here is one analysis of one plant, not all the plants. Not all plants work the same way. They're designed that way, and so it would be probably better to look at different types of plants. The other thing I'll point out is that a lot of my risk calculations are hand calculations. It needs to be full logic model treatment, full treatment of uncertainties, the way we normally calculate things.

MEMBER KRESS: If your risk numbers in your calculations came out to be something that gave us second thoughts, in my view, that would put a flag that this might be a generic issue that we need to think about for all the PRAs or all the plants. It has nothing to do with a particular plant at the moment, like Vermont Yankee, to say, because you're dealing with design-basis space. And once you -- what I've been doing here is question the adequacy of design-basis space to provide adequate protection, so that would lead to a generic issue, I think.

MR. STUTZKE: Right.

MEMBER KRESS: Okay. I just wanted to be sure I'm thinking in the right vein.

MR. STUTZKE: Yes, I agree with you. I'm just trying to say I'm reluctant to dismiss the issue, or actually reach a conclusion that we don't have a problem with adequate protection on the basis of a single calculation like --

MEMBER KRESS: I think it would be a good thing to find out, because this is one of those things where you're validating the design-basis space to render you in a good acceptable safety, and I think it's always a good thing.

MR. STUTZKE: Right. And that's the reason why I said this morning, I think in the future when licensees request credit for over-pressure, we want to see the risk calculations. We want to see something, we want to see it addressed somehow. Now I'm done.

MR. LOBEL: Dr. Wallis, there's somebody here from the Staff now that I think can address your question about debris --

CHAIRMAN WALLIS: Okay.

MR. LOBEL: If you want to spend a couple of minutes.

CHAIRMAN WALLIS: Sure.

MR. HUGHES: Very briefly, there is some public data with respect to very small, and that is really part of the GSI 191 evaluation. Now the very short version is for all intents and purposes, the types of fluids that we're looking at right now and the densities that are associated with it, it's fairly close to that of water, because a couple of the major factors within the NPSH calculations are friction loss, friction loss and piping leading to it. If I have a heavier density, more rough fluid coming through, pressure drop is going to be larger coming through the inlet piping; therefore, NPSH required is going to be a little higher. Same goes for the internals of the pump. As the internals of the pump are spinning around, because of the density of the fluid, because of the additional friction within the impeller and those types of things, you are going to have a slightly larger NPSH --

CHAIRMAN WALLIS: I think the bigger effect would be the nucleation and the bubble growth.

MR. HUGHES: The testing that's been done for all intents and purposes for mixtures that we're talking about - and a lot of this comes from the mineral mining industry having to do with sandpipers and things along that lines - as long as it's close - now what's close? It's close as in you're pumping dirty water out of the bottom of a sump, or out of the bottom of a mining shaft - and that's, again, where most of this information comes from - it's close. It's close to the point where when you're calculating the numbers, it's not conservative, but it's reasonable.

CHAIRMAN WALLIS: Well, this debris has maybe zinc particles from the paint, which are actually producing hydrogen by interacting with the material in the pool, and so you've got particles with some gas maybe attached to them, which act as nucleation sites for bubble growth. It seems to me much more of an effect than the effects you've been talking about.

MR. HUGHES: Which is not a lot different than methane bottom of a mine shaft.

CHAIRMAN WALLIS: Maybe. Yeah.

MR. HUGHES: Okay. Or pulling water slurry out of the bottom of a wet-well.

CHAIRMAN WALLIS: And this doesn't affect the NPSH?

MR. HUGHES: It does.

CHAIRMAN WALLIS: It does.

MR. HUGHES: It does, but the studies to date say it's a minor -- it's something to be considered, something to think about. And it really becomes more of what are the friction factors and what are the piping losses in-between the suction and the pump itself. And it needs to be thought about. Most studies say it's close.

Now there are some correction factors that you can use and they're based upon the density of the slurry, if you will, as compared to the density of the water. So there are a few things --

CHAIRMAN WALLIS: Now for the Full

Committee, would you have some quantitative information where you actually have a reference and some kind of numbers that you can pull?

MR. HUGHES: I have some references, some conference proceedings of the last three or four years from the Mineral Society.

CHAIRMAN WALLIS: And these will show the curves for here's clean water, and here's dirty water, and it's the same.

MR. HUGHES: With hard particles, that sort of thing.

CHAIRMAN WALLIS: Okay.

MR. HUGHES: There are some publicly available --

CHAIRMAN WALLIS: Sure, that will be useful, I think.

MEMBER DENNING: I do think, though, there still is the question that you're raising here, and that is whether the questions of nucleation are important or not. They might actually be in the opposite direction, and that's superheat, and it might be worse and this may prevent from getting superheat. But that would be interesting to see if there's anything on that, as well.

MR. HUGHES: I'll provide the references

to Rich. But the conclusions to date have been there is an effect, albeit a minor one, with the exception of the --

CHAIRMAN WALLIS: Well, since it's a long time between now and September, maybe you could get the key information to Ralph in some form that we could review.

MR. HUGHES: That's fine.

CHAIRMAN WALLIS: And it's best if it's quantitative and based on tests or something, and not qualitative and speculative. There's actually real evidence, that would be very good.

MR. HUGHES: I will send Ralph what I have.

CHAIRMAN WALLIS: Thank you.

VICE CHAIRMAN RANSOM:: One thing that may be saving in the pump is that the cavitation occurs in the low pressure regions, and they're associated with moving surfaces, you know, the blades. And consequently, the most likely place for the cavitation to begin is on the surface. And there are, of course, nucleation sites on the surface itself. But there's a lot of evidence of that, even with cavitating in tories because you don't get homogeneous nucleation. It doesn't occur throughout the fluid. It occurs right on the surface where that curve has led to a low pressure region and vaporization occurs. And so if you kind of use that argument, you expect that the particulate matter probably doesn't make much difference, and that's what he seems to be saying. I don't know if those pumps are the same as the kinds of pumps that were used in nuclear power plants or not. That would be of some interest. Another data point would be irrigation pumps. They pump dirty water all the time with only a few feet ahead on the inlet. And they run for days, and days, and days.

MEMBER SIEBER: I think in the manufacture of pumps, the manufacturer designs a pump suited to the application. And there are techniques that can be used, like water flush bearings, independent lubricating systems and so forth that will protect the pump against the effects of abrasion and wear. The question is are the pumps that are applied in nuclear power plant situation designed with the facts in mind that the water may not be clear and pure. And I don't know the answer to that question.

CHAIRMAN WALLIS: Now how are you going to handle these sort of points that were raised from the public this morning? Are they going to appear as public comments on this document when it's issued, and then there's going to be some Staff response to each one of them? Is that what's expected?

MR. LOBEL: Well, in terms of the public, we made the documents available after we sent them to the committee so that the public would have them to be able to better participate here, but after receiving your hopefully positive letter, then they'll go out for public comment, and then the public can comment on them then, and make whatever comments they want. We specifically said in making the documents available to the public that this wasn't the beginning of a public document period, so I guess I would say --

CHAIRMAN WALLIS: So this presentation here doesn't get rebuttal from you until it's repeated as public comments in some form. So nothing much will happen for six months or something.

MR. LOBEL: I can address some of it, if you'd like, but in terms of comments, there'll be plenty of time for them to comment on the Reg Guide when it's out for comment.

VICE CHAIRMAN RANSOM:: Are there any requests for any further time for stakeholder comments?

MR. CARUSO: Yes. We have a request from Mr. Shadis and Mr. Appleton, and Mr. Sherman would like to come back for the hearings.

MR. LOBEL: Well, we need to move ahead with that, I would say.

MEMBER SIEBER: Thank you.

MR. HUGHES: I had some conclusion slides, but we've already I think stated each one of them a couple of times, so I'll just leave.

MEMBER SIEBER: Thank you very much. I can see a lot of effort has gone in --

CHAIRMAN WALLIS: Well, I think the conclusion that you want us to reach is that the new version of Reg Guide 1.82 is appropriate and responds to all the shortcomings of the previous Reg Guide. Isn't that the conclusion you want us to reach, rather than the conclusions that you've reached here? You want our letter to state that we don't see any great impediment to this revision to the Reg Guide as we've seen it today, or whenever we think that it -- we don't see anything that we need to raise as a problem at this time. Is that the kind of thing you want to get from us?

MR. LOBEL: Yes, I think so. Like we've

been saying, the actual changes to the Reg Guide that affect policy and the way we would do reviews are really the only new changes. The other stuff is just adding more information for people, technical information. We, in the past, presented the issue of containment pressure credit, and gotten a positive response with a caveat. We tried to address --

CHAIRMAN WALLIS: That was six years, or eight years ago or something.

MR. LOBEL: Well, I guess that's up to you how you want to treat it. We made the effort to go through the whole case again just because we recognize it's been a long time, and we think this is probably the most complete assessment of this issue that the Committee has heard. I read the previous transcripts, too, and I can't say I was all that happy with some of it either, so we tried to give a complete response. I guess it's up to you how much you want to go back and address the issue of over-pressure completely again.

MEMBER SIEBER: Well, this sort of takes the form of an interim letter. Our final letter that would say this is good or not good will come after public comment.

MR. LOBEL: All we're asking for is to go out for public comment now.

MEMBER SIEBER: And basically, we would write a letter if we saw some major impediment that would affect the ability of the public to make comments that were adequate because if we withheld a major comment until after the public comment period, it may alter the draft guide so much that you would have to go out for additional public comment, so I think the purpose of today's meeting and a Full Committee meeting is to identify any show-stoppers at this point in time. Or as an alternative, tell the Staff it's okay to go out for public comment.

CHAIRMAN WALLIS: What we're really saying, it's okay to come before the Full Committee in September.

MEMBER SIEBER: Well, that would be what we would say today. We wouldn't write anything until September.

CHAIRMAN WALLIS: We don't make a decision about going out for public comment.

MEMBER KRESS: It's hard to say what the Full Committee will do. I learned that on some other --

MEMBER SIEBER: Typically, what we say is that we decided not to do the full review at this time, and so this would be considered a partial review because we don't know what the public comments will be. But we would like the opportunity to review when the public comments are received and resolved.

MEMBER SHACK: I mean, the Reg Guide, or at least when you send it out, you're going to have to ask for some comment from the public on the uniform aspects of it since it's really not addressed directly in the Reg Guide. You could do that --

MR. LOBEL: I think the -- I don't know what the procedure would be, but it seems like it would be beneficial to make some changes in the Reg Guide from the version we presented to you. And maybe, if it's possible, I think maybe I answered a little too fast about the other comments that were made today. We could consider those -- rather than rebutting, we could consider those before we send out the version for public comment, since we've gotten some -- we've heard them now.

The other thing is I think we wanted -- you didn't put anything in about risk because back when this was done, the idea was that it wasn't necessary. But in reconsidering that, we've decided that -- Marty's decided that we should have something in there so that risk is considered with every application, and so I think we want to put that in before it goes out for public comment.

MEMBER SIEBER: I think without consideration of risk, your case is not as solid as it could be.

MR. LOBEL: Well, it wasn't --

MEMBER SIEBER: I think risk really helps put things in perspective, to say what's important and what is not important.

MR. LOBEL: It wasn't that we were leaving it out. It was that we thought we could make the case without having to make the case on every single application.

MEMBER SIEBER: I don't know whether that's true or not.

MR. LOBEL: We don't either, so now we're going to make it part of every application.

CHAIRMAN WALLIS: Well, this new Reg Guide says if you make all these conservative assumptions and convince the Staff that they are conservative, and you come up with positive suction head, which meets the margin with this ratio of what you get to, what you need of one, then it's acceptable. And then you may even get more if you've got curves you can justify. I think the trouble will come if plants find that making all these conservative assumptions, they want to back-off on some of those conservative assumptions for some reason.

MR. LOBEL: I agree, yes.

CHAIRMAN WALLIS: Making them all seems absurd, so we'll only make the first two that really matter.

MR. LOBEL: And then the issue of margin becomes more --

CHAIRMAN WALLIS: Then the issue is well, is that good enough and so on. I think it would help, as I said before, when you come before the Full Committee if you could say -- you've got all these 15 conservative assumptions, but these are the ones that really matter. And this is how much they're worth.

MR. LOBEL: Well, I don't know if we'll be able to do that by then, but we'll try.

CHAIRMAN WALLIS: A perspective on what's involved. There's an awful lot of loose talk about conservative assumptions.

MR. LOBEL: Well, I think it isn't so much a question of if they're in the conservative direction. I think it's more of a question that you were raising of what their values are and how much --

CHAIRMAN WALLIS: If they're all trivial, if what you get from being conservative is trivial, and you're much more uncertain about something else, then really it's not very convincing.

MEMBER SIEBER: Well, the interesting thing about that, and I guess I've thought about it a little bit over the years, people do make conservative assumptions or bounding calculations because it's difficult to do the realistic one and assign an uncertainty to it. That's orders of magnitude more difficult than just making a bounding calculation and declaring it conservative. And the problem is, without the realistic calculation and the uncertainties, compared to the bounding calculation, you don't know what margin you have, so when you say well, I've got plenty of margin, I don't know what that means. Obviously you have some margin, but unless you have either experimental data or a good thorough realistic calculation, including uncertainties, you don't know what you're measuring. And I would prefer to know what the margins really are.

CHAIRMAN WALLIS: Now these pumps aren't run very often, are they, in a nuclear plant?

They're only run when they're needed. Are they tested from time to time or something?

MR. LOBEL: They're probably tested.

MEMBER SIEBER: In BWRs recirculation spray pumps do not --

CHAIRMAN WALLIS: You have to run them every so often?

MEMBER SIEBER: Once a cycle to make sure that it starts.

CHAIRMAN WALLIS: So there's no reason to suppose that they've degraded after sitting around for 30 years?

MR. LOBEL: Well, that's why they're tested quarterly, to make sure that they're not degraded.

CHAIRMAN WALLIS: They don't test NPSH, do they?

MEMBER SIEBER: No.

MEMBER DENNING: No. As a matter of fact, I think there's a little story here, and I hope I get it straight. But in Surrey, when we did WASH-1400, of course, the heat removal comes from the spray, the long-term heat removal comes from the spray system.

MEMBER SIEBER: Containment heat removal.

MEMBER DENNING: Containment heat removal. Of course, we gave it full credit for that. But subsequent to WASH-1400, it was discovered there was a design error in that pump, if I've got this straight. And the reality was the NPSH was not properly designed for that pump, and it would not have worked. Subsequently fixed.

MEMBER SIEBER: I don't know that.

MR. HUGHES: Again, Steven Hughes. ASME Code require testing quarterly on these types of pumps. These are considered Group B-type pumps, so in general, containment spray pumps, RHR pumps which are not operated during normal operation are tested quarterly. If they're at a point that's generally picked at a well-sloped point on the curve, it needs to be repeatable. They monitor in the older versions of the code, DP flow and vibrations. In the newer versions of the code, it's a little bit less rigorous in that for these types of pumps, for every outage every two years, they're required to run a comprehensive pump test, which is required to be run at approximately 100 percent of their design flow. The actual code requirement is designed for plus or minus 20 percent, so the pumps that we're talking about - do they degrade over time? The answer to that is they are monitored, and they are looked at. And if there is a problem, there are certain requirements by the code, and by 10 CFR 50.55(a) that require them to take actions. So yes, they are monitored for degradation. Yes, they are looked at. And in most BWRs, most BWRs have full flow test so that quarterly test is generally run at design flows. PWRs are a little different, but from a BWR standpoint, for most of these tests, the pumps are run at full flow quarterly.

MEMBER SIEBER: Generally speaking, based on working in a plant for many years, pumps that aren't ordinarily run except for quarterly testing or flow testing every 18 months, you don't see wear in things like wear rings, impellers, pump casings. If you see degradation, it occurs in the bearings and seals. And the seals, if it's a mechanical seal, it may dry out. The bearing may pit, and other than getting more leakage than you would like, which these would be detectible during even standby conditions, a pitted bearing really doesn't hamper the short-term operation of the pump.

VICE CHAIRMAN RANSOM:: I would like to move ahead to the stakeholder comments, give them time.

MR. LOBEL: Do you have a handout?

MR. SHADIS: I don't.

MR. LOBEL: Your name, please?

MR. SHADIS: My name is Raymond Shadis, S-H-A-D-I-S. I represent an organization called the New England Coalition, which is a non-profit membership group that is incorporated in the State of Vermont. My position with the New England Coalition requires me to track environmental and safety issues at New England's nine nuclear power stations, five operating stations, four in decommissioning, two of those are BWR Mark-1s. That would be Pilgrim Station and Vermont Yankee.

I do want to thank the committee for entertaining our comments. We were very pleased to receive a call from Mr. Caruso asking us if we would like to present at this meeting. And by way of preamble, I will say that I'm glad that we're speaking toward the end of the meeting, because so much has been said that we would have said, and it's also been educational, and at times entertaining, also.

We have some very deep concerns with this proposed Reg Guide change, and they would not be necessarily allevied by refusing the change, or denying the change because the history of this goes back just a little way. What in our view is happening here, is that there is a problem that has surfaced, and which NRC and the ACRS are being asked to address. The problem goes back a very long way, and it goes back to a time when there was a basic design error.

It's hard to fathom that anybody in the procurement department of an architect/engineering firm building one of these BWRs, early BWRs, would have ordered a pump with the intention that it should be cavitating pump, able to slop just enough water into the core to cool it. What we have here is a design specification that call for a pump that could operate at, I presume, atmospheric pressure, and deliver water in excess to cool the core. And there's no way that you can look at this and not say that acceding to containment over-pressure in order to accomplish some part of that purpose isn't a step back in terms of safety. It may be small, it may be incremental, and you might juggle the numbers enough to actually come up even steven, but it certainly isn't an advance in reactor safety for either -- both for accident mitigation or recovery either way.

In fact, we're confused as to whether

this is an attempt to permit a procedure or legitimize a procedure. And if it's a case of legitimizing the procedure, as I suspect it is, then it's tantamount to getting a birth certificate for a 20-year old, to legitimize the child.

I have a report which I recommend to you, and unfortunately I only have one copy, and I grabbed it off the shelf on the way out the door yesterday. But this is a -- it's titled "Vermont Yankee Containment Safety Study - August, 1986." And it came with a cover letter to Mr. Harold Denton, the head of NRR at the time, so dated September 2nd, 1986.

The report --

CHAIRMAN WALLIS: Who is the author of the report?

MR. SHADIS: This is from Vermont Yankee.

CHAIRMAN WALLIS: Oh, from the licensee?

MR. SHADIS: Yes, it is. "In accordance with our commitment, contained in the reference letter, enclosed find our completed Vermont Yankee containment safety study. Represents a 60-day effort on the part of Vermont Yankee and consultants to compare Vermont Yankee design features to those in the reference plant in WASH-1400, and calculate specific containment conditional failure probability, and address the five BWR containment issues raised by Mr. Benaro of NRC last June."

I want to point out that in this report, which is, I think, a really fine little report, Vermont Yankee specifically raises the question of venting the containment, or of employing the containment spray; and, thus, reducing containment pressure and losing net positive suction head. This is something that was recognized at the time. This was something that the licensee and their operators must have - because I've got a great deal of faith in them - they must have taken cognizance of this and incorporated it into their procedures.

In fact, it says "for anticipated transient without SCRAM, Vermont Yankee" -- it basically says that they have incorporated into their EOPs consideration of not reducing containment pressure, and I presume not down to zero. Other issues that are raised in here are of significant --

CHAIRMAN WALLIS: I think in terms of where they stand now, that is fine. And then in terms of the power uprate, it might be to get credit for over-pressure in the containment. But as far as operating today, I think it is okay in terms of what you say there.

MR. SHADIS: Well, it may be okay in terms of its actual effect, mechanical effect, that indeed they can get away with maintaining some containment pressure in order to make certain that the pumps don't cavitate. But at the time this was written in 1986, that was illicit. That was not part of the guidance.

CHAIRMAN WALLIS: They didn't need over-pressure.

MR. SHADIS: Pardon me?

CHAIRMAN WALLIS: I don't think they needed over-pressure at the present power level.

MR. SHADIS: Well, this report contradicts you in the sense that what they are saying in the report - and I do hope you'll have NRC Staff get you copies of it - but our interpretation of it is that they do, indeed, need to retain some containment pressure.

CHAIRMAN WALLIS: They actually bar over-pressure in 1986?

MR. SHADIS: Yes, sir. And there are several references to it throughout the report. The other thing in here that jumped out right away is that the -- we had some confusion between two speakers here from the NRC. I distinctly thought I heard the first speaker say earlier on that raising the water temperature would not necessarily act toward inducing cavitation. That you would not have vaporization and boiling of the water by raising the temperature. And that was strictly counter-intuitive. I was glad to hear the second speaker say the opposite thing.

CHAIRMAN WALLIS: It depends which part of the equation you put it in, I think.

MR. SHADIS: Quite so. And Vermont Yankee makes that admission here. The concern with keeping the suppression pool water temperature low in order to avoid loss of net positive suction head cavitation, so I recommend that to you.

I want to - here's a lay person talking to you - and thank you for allowing me to do that. I just want to make the point that with all of the BWRs that have already been permitted to take credit for containment over-pressure, one would presume they're going to use that, that they're going to employ that. And in tables provided by the State of Vermont, just a quick look at it says that the over-pressure typically is at 5-1/2 to 6-1/2 PSI. And this is moderate and it's modest, but it needs to be considered in terms of a platform from which containment pressure goes up under accident conditions.

The Vermont Yankee's tech specs, for example, talk about venting when the containment pressure reaches 58 PSI. I personally think it would automatically vent sometime before that, but that's their estimate. So it's a non-conservatism. It has a negative safety impact to presume that you're going to start into that sequence with a 5-1/2 to 6-1/2 pound head start. And there are accident scenarios where you can get a surprise.

This particular containment does have -- it is inerted. In the tech specs, the oxygen levels are cut to about 4 percent with the stipulation that when you get up to 5 percent, you start to move into combustible space for hydrogen. That 4 percent inventory of oxygen doesn't take into account the addition of oxygen through zirconium hot water, or zirconium steam reaction. It's not much to go that extra 1 percent or even 2, to make it a situation where you can get a hydrogen burn. And we're reminded that the two spikes at TMI, I think the larger spike at TMI was 28 pounds per square inch, and in a big containment. So we looked at this, and we wonder if NRC and the licensee aren't heading into space where there could be some unanticipated consequences, and some unpleasant surprises.

I'm just trying to flip through to the few remarks I wanted to say. I guess I would wind this up here. I mean, there's a lot to be said about the fact that you have been handed a design error and asked to amend the rules and regulations, or the guidance, if you will, to take care of a mistake that was made many years ago, and one which does have its negative safety implications. And you're now being asked to legitimize a practice that has been in place for 20 years or more, sometimes with NRC granting exemptions, sometimes the licensee simply went ahead and handled this as best they could.

I want to reiterate again that when we look at the trend in regulatory adjustments at NRC, big picture stuff, we see those regulatory adjustments only moving in one direction. Either they're static, or there are reductions in margin, reductions in redundancy, reductions in terms of defense-in-depth. There are fewer engineered productions, protections, more reliance on operator actions, and we don't see this as anything but a retreat from early safety margins.

I would ask that when you consider this, that you do not shy away from doing some case studies. Vermont Yankee would be a good one. It's practically a poster child for this sort of thing, but pick what plants you will, and look at them to see if the actual physical condition of the plant is reflected in its design documents.

We're making a lot of assumptions here about how equipment is going to perform. For example, how a torus is going to perform, suppression chamber. The one at Vermont Yankee has been altered over time. There has been welding done on it, projects that were started and then recalled. I couldn't begin to guess whether that suppression chamber is as strong as it was the day it was built or not. My guess would be not, but I don't know how much those margins have been reduced. So I think on the whole, we need to look at these things.

When it comes to leakage, someone asked a question about leakage passed the MSIVs. I don't know what the plan is at other BWRs, but it's acknowledged that they cannot secure the MSIVs at Vermont Yankee, try and try again. And so, when it comes to uprate, the cure at this point is to send the pressure downstream to the condenser, and then I presume off to the off-gas system. I don't know.

But it's going to the condenser, and we don't know if that condenser can handle it. So this whole proposition has got a chain of events tied to it upstream and downstream, before time, during accident time, and accident mitigation time, and afterward. And I think it bears more of an examination before anyone signs off on this new guidance. Maybe the new guidance should be rewritten to be more stringent than the interim guidance, but it certainly bears more examination than it's been given so far. And I thank you for your patience.

VICE CHAIRMAN RANSOM:: Thank you. Do we have any questions?

CHAIRMAN WALLIS: I think Bill Sherman wants to come up again.

MR. CARUSO: WE have two more, there's the Applicant and Mr. Sherman.

CHAIRMAN WALLIS: Mr. Sherman wants to come up again.

MR. SHERMAN: I've been conference speaker at the end of conferences before. It's a hard position to be in.

CHAIRMAN WALLIS: Get the last word.

MR. SHERMAN: Well, I never wanted the last word, but I do appreciate the opportunity to say a number of things. Actually, I wish we could have a dialogue, but that wouldn't work real well. And for the record again, I'm Bill Sherman from the State of Vermont, and I appreciate the opportunity to say some things here at the end of the meeting.

First, I'd like to take another shot at answering a question, Chairman Wallis, that you asked me earlier in the meeting. At one point you asked, this sounds like a licensee problem. Why don't you just go and ask the licensee? And with thought, I have a little better answer to that, and it's this; when you get right down to it, why didn't the licensee consider changing to more effective pumps in its pinchpoint analysis? And the answer is simple; the staff let's us do this. So our real concern is about what the staff will let them do. And we are involved in Atomic Safety and Licensing Board process where administrative law judges will make decisions, but we believe that this body may have the very best base of expertise to judge this issue. That's why we wanted to present, is because we think that you -- we're not nearly the experts that you are, and we think that if we can sort of make our concerns understood, that you will have the best tact at understanding whether there's any validity of what we're saying or not. So that's why we are anxious to talk with you.

CHAIRMAN WALLIS: Well, I would like whatever comes out of this for the State of Vermont, which is not an insignificant body, to be convinced that the right thing is being done. I wouldn't like to have a situation where one of the more responsible - and I go on for a long time about describing the State of Vermont - states in the union was at odds with the NRC over this issue. I think it would be highly desirable the NRC and the licensee to also convince you that the right thing is being done, whatever eventually ends up being done. I wouldn't like to see a residual disagreement between a state - -

MR. SHERMAN: We're trying to signal that we have high respect for this body, and appreciate that opportunity.

In brief comments, I'd like to comment on Mr. Stutzke's presentation with the slide that I have up from my packet, which is --

CHAIRMAN WALLIS: What number is that?

MR. SHERMAN: This was number 31, containment fails to hold pressure. The reason that we have this slide up is because we had opportunity to review your work, Mr. Stutzke, prior to the meeting. We had some information, and actually pulled this out because we knew something about the MSIV failure rate. The failure rate for us here in the meeting is pretty simple to discuss without having to put numbers on paper. Ten failures in 40 tries, that's a failure rate of 25 percent, eight valves must operate when the containment wants to isolate. If eight valves are operating and there's a 25 percent failure rate, two of them are not going to operate correctly.

MEMBER SIEBER: Let me interrupt a second.

MR. SHERMAN: Okay. Good.

MEMBER SIEBER: I asked the question before when you made the statements, and I feel obligated to ask it again. When you call MSIV as a failure, does that mean it leaks more than the technical specification, or it never closed?

MR. SHERMAN: It leaks more than the technical specification.

MEMBER SIEBER: Okay. That's a lot different than it failing to close.

MR. SHERMAN: Yes, sir.

MEMBER SIEBER: When you talk about eight valves, there are two valves in four lines. Right?

MR. SHERMAN: Correct.

MEMBER SIEBER: Okay. So if one of those valves failed, you still get containment isolation.

MR. SHERMAN: Correct, but --

MEMBER SIEBER: And what you have to do is to have both of them in the same line fail.

MR. SHERMAN: Right.

CHAIRMAN WALLIS: It's a simple homework problem.

MEMBER SIEBER: And a failure is leakage, I'm not sure that it has any impact.

MR. SHERMAN: You're leading exactly to my point, which is that if there are two out of the eight that fail per try, then if one of them fails in one line, and you're going to have another valve fail, you have one out of seven chance that it's going to be in the same line.

MEMBER SIEBER: But you're still talking about leakage.

MR. SHERMAN: It is true that the --

MEMBER SIEBER: And the leakage for BWR main steam isolation valves is set very low because it's containment boundary, and that doesn't have an impact on whether the containment pressure remains at its normal value or not, the kind of leakage that you're talking about. It's very small.

MR. SHERMAN: Well, in some of the tests --

MEMBER SIEBER: It's bigger because of radiological considerations as opposed to -- that's what sets that very small peak rate. You want to have containment isolation so that the mechanical parts of the system will perform as designed. And that will occur even if there is a small leakage. It's the radiological concern that sets the leakage that low.

MR. SHERMAN: Okay. But working on where I was going to go with this, and realizing that you have to look at the specific leakage rates to see how much there really was, and how much the failures were - we looked at Mr. Stutzke's valuation of this and found that there wasn't any accommodation for MSIV leakage. And that's because -- well, I'm not sure why that is, but in the fault tree that was evaluated, MSIVs weren't considered. And in the probability that you provided, you had in the order of ten to the minus three, and I think if MSIVs were included using the last five outages of data from the reference plant, you'd be one or two order of magnitudes higher with your probability than what you calculated. So that's our first point.

Here's our second point. This is Slide 34 out of the presentation. This is a start at a fault tree for pump fails due to inadequate NPSH. We stated earlier in our presentation that it is not just the failure of the containment that we're concerned about, but the overall failure - the removal of the conservatism that containment pressure gives.

What I think Mr. Stutzke was speaking about in his presentation was just the very bottom left block of this, and that is only the impact of the containment failing to hold pressure as an item that would affect pump fails due to inadequate NPSH. But in a number of these other areas, the fact that you are taking credit for containment pressure changes the probability in these boxes, or at least I think they do. And I think to get to the term significant that was used in the defense-in-depth slides, you have to do the full evaluation of the uncertainties. And I think that that's what Member Denning was speaking about when you mentioned the fact that it's more than just the containment failure. That's what I thought.

What we see is in the conservatism discussion that was done, we're concerned about what is a double counting. First, this slide mentions the margin from the standard, the 1.5 margin of actual NPSH over required NPSH that we spoke about before. I think Mr. Lobel mentioned that these pumps have fairly low suction pressures. Actually, they're considered just on the boundary of high suction pressure is what you said. And the standard --

MEMBER SIEBER: The term is suction energy.

MR. SHERMAN: I'm sorry. Thank you. Suction energy, and the standard actually for high suction energy pumps calls for a margin of 2, not 1.5. But we were willing to assume that --

CHAIRMAN WALLIS: We asked him about that, and he said this margin is for pumps which are being used for long time. He was satisfied that you could use one for these pumps, which only run for a short time.

MR. SHERMAN: Well, and I heard him say that, and therefore, that would be subject to check to see whether the standard really was there. But that leads into the cavitation discussion. We pointed out earlier that in order to avoid cavitation, the standard mentions that you need two to twenty times the NPSHR. In both presentations that we've had, both spoke as if you only got cavitation if you were less than NPSHR, the required NPSH. But in reality you --

MEMBER SIEBER: That's not true. The standard fully discusses that.

MR. SHERMAN: The standard discusses that you have cavitation --

MEMBER SIEBER: At NPSH --

MR. SHERMAN: And even higher.

MEMBER SIEBER: Yeah.

MR. SHERMAN: And so the statement that was made -- what it looks like to me in the reference plant evaluation is that they really do have their operating in the cavitation regime for close to the 55 hours that they're crediting containment over-pressure.

MEMBER SIEBER: I would say that virtually every pump in every kind of power plant, coal or nuclear, or gas-fired operates somewhat in the cavitating regime. That's the way pumps are designed.

MR. SHERMAN: And then my only other point has to do with double counting of conservatisms, and it's this. We understand the conservatisms that Mr. Lobel spoke about, and fully support that that's the way that this work should be and is done. But there's a reason why those conservatisms are there. One reason - one type of conservatism is where you either maximize or minimize heat sinks in containment, and that's because you don't really know quite how they're going to act.

Another example is the decay heat correlation, where you don't really know quite how the decay heat correlation is going to act. So the conservatism is there because of the uncertainty in the very item. Then conservatisms are provided for all these things that we mentioned. I mean, we mentioned paint chips, we mentioned pressure and temperature calcs, we mentioned possibilities in whether the NPSHR was right or not, and you have conservative calcs to account for that and unexpected events.

Finally, the single failure was listed as a conservatism, and that's something that, as I mentioned, cuts both ways. You do assume the worst single failure, and that is a good conservatism. But the fact that you only assume one failure is not necessarily conservative at all, and might be nonconservative, and that's why you have other conservatisms. And so conservatisms are like money, and for each one of these things you've paid out a little money out of your conservatisms. And then rather than have margin for NPSH as the standard mentioned, the draft Reg Guide says that conservatisms are going to take the place of the 1.5 margin that may or may not be desirable. We see that that's a double counting of conservatism.

CHAIRMAN WALLIS: So you're saying that there are some other things that could affect performance which are not accounted for? That's not double counting, though.

MR. SHERMAN: We believe that there are some other things that are not necessarily accounted for, for which conservatism is desirable.

CHAIRMAN WALLIS: So it's rather an omission of accounting for some of these things than a double counting.

MR. SHERMAN: Using conservatism for the NPSH margin that may be desirable, we see as a double counting.

CHAIRMAN WALLIS: So I think you're saying if you took account of all these things, you get down to one because you've taken account of all the things which could make it less than you thought it was. You're saying there are some other things, which might essentially get you below one that you haven't accounted for; therefore, you should try to have these things which bring it down - not bring it down below 1.5, because the 1.5 gives you this .5 to account for the things that you haven't thought of. Is that what you're -- am I being worse than your explanation?

MR. SHERMAN: I think you're explaining it just fine. And another way of explaining it is that you had all these conservatisms, including containment over-pressure. And then you're going to add with extended power uprate 20 percent more energy into the system, which means that it's a less conservative item. So you're going to then take more conservatism, and what you're taking away there is you're taking away the over-pressure that you had as a conservatism. Again, it's a little bit of a double counting. But those are the points that I wanted to make, and I really do appreciate the time that you've given the State of Vermont, and we appreciate your consideration of the issue.

MR. CARUSO: I'll take care of that.

MR. LOBEL: Any other stakeholder

comments?

MR. CARUSO: Mr. Atherton, if you want to make a comment.

MR. ATHERTON: If I could, please. My name is Peter James Atherton.

MEMBER SIEBER: Maybe you could sit at the table. I have trouble hearing.

MR. ATHERTON: My name is Peter James Atherton. A little bit of background on myself - I used to work for the Atomic Energy Commission and the Nuclear Regulatory Commission in the 1970s, and I --

CHAIRMAN WALLIS: You weren't responsible for RG 1.82, though, were you?

MEMBER SIEBER: Safety Guide 1.1.

MR. ATHERTON: Well, my specialty then was electrical instrumentation and controls. I went to plant systems, and I ended up in fire protection. So I basically have a general view of --

CHAIRMAN WALLIS: Out of the frying pan into the fire.

MR. ATHERTON: Something like that. This is my first involvement with the thermohydraulic arena in quite a few years, so I'm going to limit my comments to -- well, actually I had some questions. I'm going to put them in the form of comments for suggestions that I received.

I'd like to start with the single failure criterion. Back in the mid-70s, one of your constituents, a Dr. Steven Hanauer who used to be with the ACRS, later served as Technical Director or Technical Advisor to the Executive Director of Operations, wrote a memo to Guy Arlotto in which he basically asked Arlotto to put on hold a suggestion that he was trying to propose to eliminate the need for single failure criteria on the basis of probabilities. And Dr. Hanauer's reasoning at that time was that probabilities can essentially be abused. They can be used to justify anything, and this was right after the Brown's Ferry fire, which he was involved with in evaluating, and starting up the fire protection program. And so he had a personal feel for how probabilities could be used and abused back in those days, and this is not intended to supplant anything that Mr. Stutzke has presented today. I'm just providing this as information from my days with the agencies back in the 1970s.

Taking this to the single failure criterion, well, at least in the electrical department, there was a strong desire to have a single failure include multiple failures if there was the possibility for common mode failures. And there was -- I guess the criteria for a nuclear power plant adhering to the 1967 criteria, the general design criteria first proposed back then, which turned out to be 10 CFR 50, Appendix A, today, had a number of contentions, one of which was what the definition of single failure would be. And I have not seen anything other than one failure of an active component would be considered a single failure in the discussions here today. And not being actively involved with what's happened over the years on a continuing basis, I still have some concerns that by not considering this, we are necessarily limiting ourselves to something that is not realistic, as Mr. Wallis has been pointing out during the course of the day.

CHAIRMAN WALLIS: So you're think that there are some common mode failures in this NPSH scenario which have not been considered?

MR. ATHERTON: I'm not going to get into the details of this. The only thing I'm noting for comment purposes is that common mode failures were not even looked at from the perspective of my point of view, except possibly for Mr. Stutzke's PRA analysis, which surprised me to some extent, but I am also kind of curious. Back in those days I was a technical reviewer, for all practical purposes I did technical reviews, and the licensees during the licensing process were a bunch of plants which had come in with applications for construction permits and operating licenses during these days, and they were required in the early 70s at least to provide a failure modes and effects analysis. And I've seen no mention of that at all in this meeting, and if this was recognized as even somewhat of a problem back in those days, a failure modes and effects analysis should have addressed it to some extent. And if they are now taking credit for problems created by an accident, it seems to me there should be a mechanism whereby that failure modes and effects analysis can be looked at differently now that they're taking credit for something new that they didn't take credit for back during the licensing phase. So my comment is why isn't the licensee being required himself to provide the equivalent of a failure modes and effects analysis for any changes that he's making to his plant taking credit for something that he did not analyze for previously.

And one thought that I have, which kind of is important to me from my representations which

I get involved with today, and that is what the public is concerned with. And their primary concerns are not necessarily with how the plant operates, or doesn't operate. It's whether or not it's going to emit radiation to the environment. And in the PRA analysis there was no consideration apparently taken into account from the public's perspective as to what would happen if the containment were breached, and radiation was released to the environment in any PRA analysis. That ultimately is what NRC is here to prevent from happening, and it has not addressed the issue from that point of view, so that's a comment that goes --

MEMBER SIEBER: Let me ask a question. Are you asking us, or asking the Staff to go the extra step to a consequence analysis from a core damage and breach of containment? Or is it just good enough to know that you've got core damage and a breach of containment with a certain probability?

MR. ATHERTON: From the public's perspective, and questions I get again are not how the plant operates or doesn't operate, it's what happens to the radiation that it releases. It would seem to me that since NRC is in the position of protecting public health and safety against at least excessive doses of radiation, that any conclusion that they come up with should be directed toward that end.

MEMBER SIEBER: Well, CDF and LERF are surrogates for basically the health effect and so you'll see those more frequently in the regulations, than the ultimate consequence, since they are used as surrogates.

MR. ATHERTON: Okay. So my comment goes to the fact that there's no -- the end result, you seem to have not gone that extra step to tell the public as a result of whatever you're doing here, radiation to the environment is going to be whatever it is.

And one last comment is during the vigorous days of reviewing nuclear power plant applications, the worst case scenario was something that was always looked at, and what everything was reviewed to. And determining that worst case scenario for whatever the safety consequences might be was always problematic. I don't hear that happening at all. I don't perceive the use of a worst case perspective. It's all in today's terrorist environment, after all this nation is technically at war with terrorists wherever they are, terrorism against nuclear power plants is a real-life situation we should be considering. It poses threats that, at least in this meeting, we're not even looking at. And I'm wondering if in the real world we should be considering that from the perspective of any design changes we make for other reasons. I realize this has some connotation with regard to security matters, so I'll leave my comments at that point. And I thank you for permitting me the opportunity. Are there any questions you have of me at this time? Thank you.

MEMBER SIEBER: Thank you very much.

VICE CHAIRMAN RANSOM:: I think we're down to the staff, or I mean the committee discussion part. Do you want to do that off the record?

CHAIRMAN WALLIS: Can we be off the record for discussion?

MR. CARUSO: We could do that.

CHAIRMAN WALLIS: Yes. Okay. We can do that.

MR. CARUSO: Go off the record.

(Whereupon, the proceedings in the above-entitled matter went off the record at 5:06:35 p.m.)

CERTIFICATE

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

Name of Proceeding: Advisory Committee on Reactor Safeguards Subcommittee on Thermal Hydraulics

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.

ACRS Thermal-Hydraulic Subcommittee

Containment Overpressure Credit

July 19, 2005

Bill Sherman – VT Dept of Public Service
David Lochbaum – Union of Concerned Scientists

Introduction

* Vermont's interest in the overpressure credit issue

* Understand this meeting is on the generic issue (rather than plant specific)

* At times we will refer to a "reference" plant as an example

Overpressure Credit History

* RG 1.1 and early regulation
* Sump/Strainer issues
  USI A-43 (1979-1985)
  BWR Round 2 (1992-1998)
  GSI-191 (1999-present)
* ACRS Jun 17, 1997 (no credit) **[ref. 1]**
* ACRS Dec 12, 1997 **[ref. 2]**
  (selective, small amounts, few cases)
* Extended Power Uprate Approvals (2001)
* Regulatory Guide 1.82, Rev 3 (11/03)

ACRS Statement: Dec 12, 1997

- "We now concur with the NRC staff position that selectively granting credit for small amounts of overpressure for a few cases may be justified."

ACRS Statement: Dec 12, 1997 (cont.)

- "We recommend that instead of using qualitative arguments and restricting attention to a limited range of accident sequences, the decision making process should consider the time variation of NPSH for a broad range of accident sequences such as typically found in a probabilistic risk assessment (PRA)."

Current Overpressure Credit Guidance (RG 1.82, Rev. 3)

- No overpressure credit except:
  - Where needed
  - Design cannot be practicably altered
- NRC staff has not been following, and today proposes to modify the guidance
- VT believes guidance should not be changed – will state reasons why

VT Presentation: We will show . . .

- Defense in Depth should not be compromised by creating barrier dependencies unnecessarily
- The concern is not just that the containment might fail . . .
- but also that the uncertainties are great enough so that the NPSH conservatism that containment overpressure has always provided should not be abandoned unnecessarily

VT Presentation:

- While there may be reasons for "selectively granting credit for small amounts of overpressure in a few cases,"
- Extended Power Uprate is a voluntary endeavor that does not create a **necessity** for allowing containment overpressure credit, and
- There are **practicable alternatives** for Extended Power Uprates to avoid crediting containment overpressure.

A Word about Need and Alternatives

- Backfit rule: 10 C.F.R. §50.109
- Overpressure credit may have been considered "necessary" under backfit rule applicability
- EPU is not under the backfit rule
- EPU "pinch point analysis" – millions spent for percentage increases [ref. 3]
- In EPU, there are practicable alternatives

Altering Traditional Defense in Depth Barrier Philosophy is Undesirable

- Three Barriers
  - Fuel Cladding
  - Reactor Coolant Pressure Boundary
  - Containment Boundary
- Overpressure Credit – Dependency Containment Boundary/Fuel Cladding
- Three-Barrier concept deeply embedded in nuclear safety philosophy

Altering Traditional Defense in Depth Barrier Philosophy is Undesirable (cont)

- ACRS Letter May 19, 1999 [ref. 4]

"The uncertainties that are intended to be compensated for by defense in depth include all uncertainties (epistemic and aleatory). Not all of these are directly assessed in a normal PRA uncertainty analysis."

Uncertainties - We will discuss uncertainties associated with:

1. Maximizing Temperature and minimizing Pressure
2. Adequate NPSH margin
3. Debris head loss
4. Required NPSH
5. Operator confusion
6. Unexpected containment phenomena
7. Inadequacy of the single failure assumption
8. PRA issue of accounting for the unexpected

Uncertainty #1: Maximizing Temperature and Minimizing Pressure (cont.)

- Calculations to maximize temperature and minimize pressure are complicated
- Have not been done consistently in the past
- Proposed guidance is inadequate

Uncertainty #1: Maximizing Temperature and Minimizing Pressure (cont.)

- Heat transfer to containment structures
- Containment leakage
- Containment sprays
- Containment cooling units
- RHR heat exchanger heat transfer rate
- Heat and mass transfer to containment atmos
- Decay heat calculation
- Fouling and aging mechanisms
- Amount of water addition

Uncertainty #1: Maximizing Temperature and Minimizing Pressure (cont.)

"Regulatory guidance for determining the minimum containment pressure at the time that pool temperature peaks has not been established. Several utilities, at least, have used calculations with simplifying assumptions that cannot be justified." *

page 5-28

* Clint Shaffer and Willard Thomas, Science and Engineering Associates, Inc., "Technical Assistance Related to ISA Issue No. 5: Reliance on Containment Overpressure for Ensuring Appropriate NPSH," SEA 97-3705-A:5 (ADAMS ML050340037)

Uncertainty #1: Maximizing Temperature and Minimizing Pressure (cont.)

"SEA did not find the DAEC overpressure analysis adequate because the analysis was overly simplified and did not consider all forms of containment cooling, such as heat transfer to the structures, and other time-dependent processes."

page 5-9

Uncertainty #1: Maximizing Temperature and Minimizing Pressure (cont.)

Table 5-8: Alternate Maximum Cooling Calculations

Case No.	Flow from RCS	Decay Heat	Cont. Sprays	RHR Heat Exchanger			Cont. Struct.	DW Fan Coolers	Cont. Leak-age
				Prim. Pumps	Service Water Pumps	Heat Trans. Coef.			
1	LOCA	Cons.	100/0	1	1	Cons.	No	Off	No
2	LOCA	Cons.	100/0	1	2	Cons.	No	Off	No
3	LOCA	Cons.	95/5	1	2	Cons.	Yes	Off	Yes
4	LOCA	Cons.	95/5	1	2	Cons.	Yes	On	Yes
5	LOCA	Best	95/5	1	2	Cons.	Yes	On	Yes
6	LOCA	Cons.	Off	1	2	Cons.	No	Off	No
7	ADS	Cons.	100/0	1	2	Cons.	No	Off	No
8	LOCA	Cons.	100/0	2	2	Cons.	No	Off	No
9	LOCA	Cons.	95/5	1	1	Cons.	No	Off	No
10	LOCA	Cons.	100/0	1	1	Cons.	No	Off	Yes
11	LOCA	Cons.	100/0	1	1	Best	No	Off	No

Uncertainty #1: Maximizing Temperature and Minimizing Pressure (cont.)

Flow from RCS All cases assumed a large LOCA except for Case 7 for which the ADS was assumed to open immediately instead of a LOCA so that the RCS flow entered the suppression pool rather than the drywell.

Decay Heat All cases except Case 5, assumed the conservative-estimate decay heat correlation discussed in Section 5.3.1. Case 5 assumed the best-estimate decay heat correlation.

Containment Sprays Three options were modeled for the containment sprays. In the first option (denoted as 100/0), 100% of one RHR train was sprayed into the containment drywell. In the second option (denoted as 95/5), 95% of one RHR train was sprayed into the drywell and 5% is sprayed into the wetwell. The third option was no containment sprays. Per the DAEC FSAR, there are two spray headers, one in the drywell and one in the wetwell and approximately 5% of the spray flow may be directed to the suppression chamber spray ring to cool any noncondensible gases collected in the free volume above the pool. Thus, the 95/5 option to determine the impact of the wetwell sprays on containment pressure.

Number of RHR Primary Pumps All cases, except Case 8, assumed one primary side pump running on the only RHR train operating. Case 8 assumed that both pumps were running.

Number of RHR Service Water Pumps These calculations were run with either 1 or 2 service water pumps running on the only RHR train operating.

Effective Heat Exchanger Heat Transfer Coefficient One of two values was used for the product of effective heat transfer coefficient and the heat exchanger area. The best-estimate value of 6.272E5 Btu/hr-°F was calculated using the log-mean temperature difference model and the FSAR RHR heat exchanger performance data. This value was adjusted so that the base case predicted the same maximum pool temperature of 201 °F as was reported by DAEC. This reduced value was 5.6E5 Btu/hr-°F and is referred to the Table 5-8 as the conservative value.

Heat Transfer of Structures. Calculations were run with and without heat transfer to the containment structures.

Drywell Coolers Cases 4 and 5 assumed that the drywell fan cooler survived the LOCA and were used to cool the containment. In all other cases, the coolers were not available.

Containment Leakage A containment leakage model was activated in four calculations. This leakage was calibrated to leak from the drywell at a rate equivalent to 5% of the containment atmosphere per day at the containment design pressure.

Description of parameters examined in case studies (Table 5-8)

Uncertainty #1: Maximizing Temperature and Minimizing Pressure (cont.)

Table 5-10: Comparative Results for the Maximum Pool Calculations

No.	Comparison	Cases Compared		Change in Peak Pressure (psig)	Change in Maximum Temp (°F)	Change in NPSH Margin (ft-water)	
						RHR	CS
1	Conservative versus Best Estimate Decay Heat	4	5	1.8	19.8	-6.1	-6.0
2	Structures and Leakage	2	3	2.2	3.0	-2.2	-2.2
3	Leakage	1	10	0.7	0.1	-0.3	-0.3
4	Containment Sprays	6	2	2.0	0.6	0.5	0.5
5	Aligning 5% of Sprays to Wetwell	1	9	2.0	-0.1	-0.7	-0.7
6	Drywell Fan Coolers	3	4	3.3	11.2	-5.3	-5.2
7	Number of RHR Service Water Pumps	1	2	1.6	5.0	-3.0	-3.0
8	Effective Heat Exchanger Heat Transfer Coefficient	1	11	1.7	5.4	-3.3	-3.2
9	Number of RHR Primary Side Pumps	2	8	0.2	4.0	11.9	-2.9
10	LOCA or ADS	7	2	0.2	0.4	0.7	0.7
11	Largest Differential Pressure	6	5	9.4	34.6	-13.1	-12.9
12	Largest Differential Temperature	9	5	6.9	39.1	-15.9	-15.7

Point: Input assumptions on heat transfer to containment structures, fan cooler operation, etc. significantly affect outputs.

Uncertainty #2: Adequate NPSH Margin

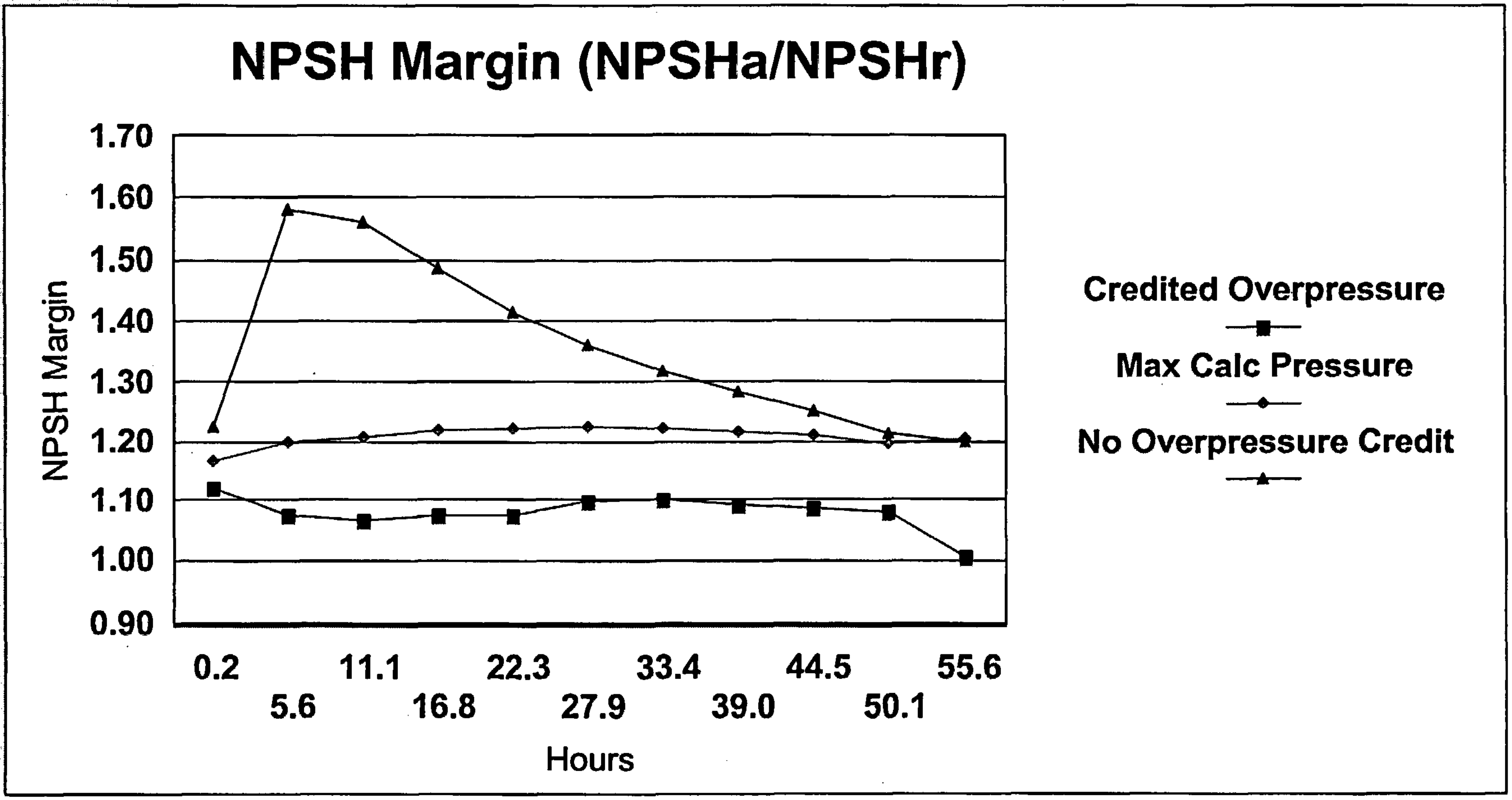
- ANSI/HI 9.6.1-1998, Standard for Centrifugal and Vertical Pumps for NPSH Margin, March 3, 1998, referenced by RG 1.82
- Table 9.6.1.1 recommends a margin (NPSH-a/NPSH-r) for Nuclear Pumps of 1.5 or 3 ft, whichever is greater. [ref. 5]

Uncertainty #2: Adequate NPSH Margin

- NPSH–r defined as the NPSH-a when flow is reduced by 3%
- At NPSH-r the pump is cavitating - significantly [refs. 6, 7]
- Extra NPSH must be available to prevent cavitating - a lot - ANSI/HI 9.6.1-1998 says 2 to 20 times NPSH-r [refs. 6, 7]
- Maximum cavitation damage point is between NPSH-r (3%) and the incipient-NPSH, closer to (a few % greater) than NPSH-r (3%) [refs. 6, 7]

Time (hrs)	0.2	5.6	11.1	16.8	22.3	27.9	33.4	39.0	44.5	50.1	55.6
Credited Overpressure	1.12	1.08	1.07	1.08	1.07	1.10	1.10	1.09	1.09	1.08	1.00
Max Calc Pressure	1.17	1.20	1.21	1.22	1.22	1.23	1.22	1.22	1.21	1.20	1.20
No Overpressure Credit	1.22	1.58	1.56	1.49	1.42	1.36	1.32	1.28	1.25	1.21	1.20

Approximate Values for the Ref. Plant



Uncertainty #3: Debris Head Loss

For general reference, the Ref Plant NPSH-r is approximately 32 ft.

(For Ref. Plant)

NPSH-a	= Pressure Head	+ Elev Head	- Friction Losses	- Debris Loss
29.17 ft	= 20 ft (170^0F)	+12 ft	- 2.5 ft	- 0.33ft
19.67 ft	= 10.5 ft (195^0F)	+12 ft	- 2.5 ft	- 0.33ft

Uncertainty #3: Debris Head Loss

- Assumption of homogeneity – uncertainties of local concentrations
- Uncertainties in testing results for head loss determinations
- Ref Plant Paint Chip assumptions
- Chemical effects

Uncertainty #4: Required NPSH (NPSH-r)

- Original witness tests inadequate to determine NPSH-r – run for too short durations, no vibration readings [ref. 8]
- NPSH-r for one pump – different plant at 1780 rpm vs. 3582 rpm [ref. 8]
- Extrapolation both for speed and flow ranges [ref. 8]

Uncertainty #5: Operator Confusion

- Ref. Plant - No change in EOPs from before containment overpressure credit
- Operators reduce pressure, not told where to stop (operability curves)
- Contradictory goals – reducing pressure and maintaining pressure

Uncertainty #6: Unexpected Containment Phenomena

- Reduction of ILRT Frequency
- No tests beyond 24 hours
- Ref Plant MSIV leakage history [ref. 9]
- Containment liner corrosion

Uncertainty #7: Single Failure Assumption

- There is a high likelihood of more than one failure
- Transient History
- Emergence of common use of LCO maintenance

Uncertainty #8: PRA inability to account for the unexpected

Risk informed regulation does not consider the unknown and unexpected. Examples:

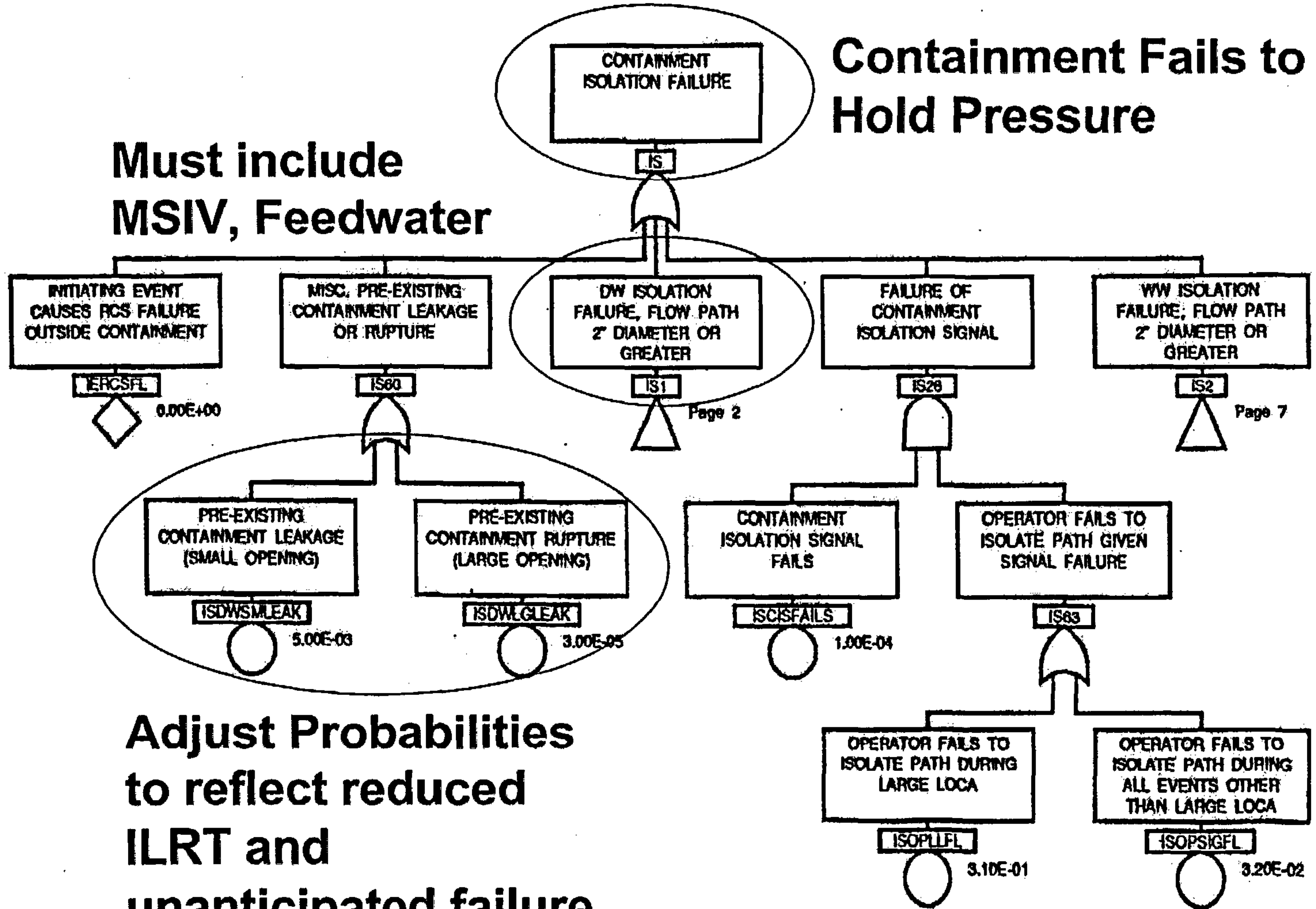
- Davis Besse
- Sump/Strainer History

Uncertainties: Summary

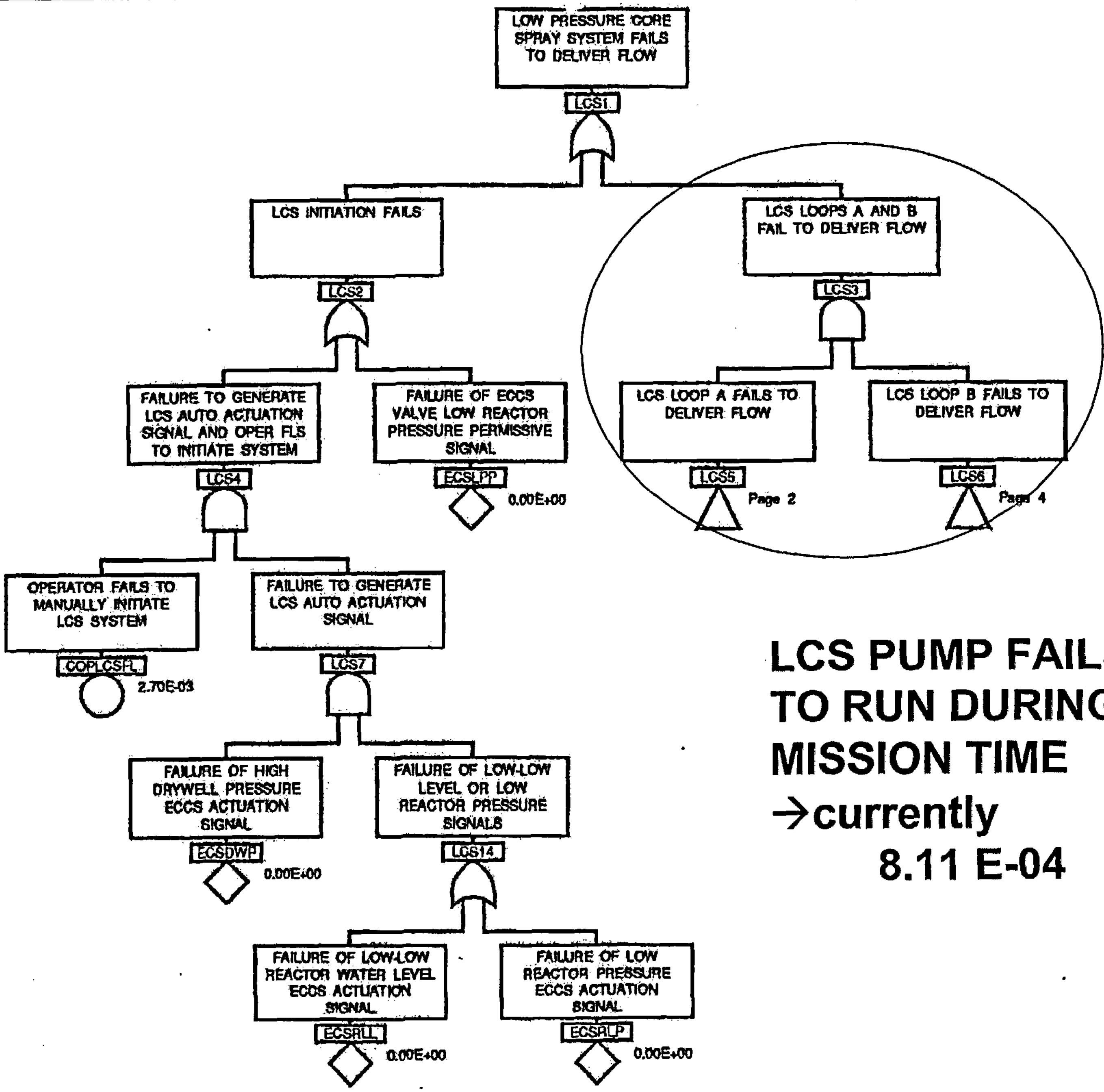
- These uncertainties are real.
- From a deterministic view, the uncertainties are great enough to direct that overpressure should be retained among the other conservatisms associated with deterministic methodology.
- From a probabilistic view, PRA techniques do not adequately account for these uncertainties. PRA analyses that adequately accounted for these uncertainties would direct that the overpressure conservatism should be retained.

Containment Fails to Hold Pressure

Must include MSIV, Feedwater



Adjust Probabilities to reflect reduced ILRT and unanticipated failure



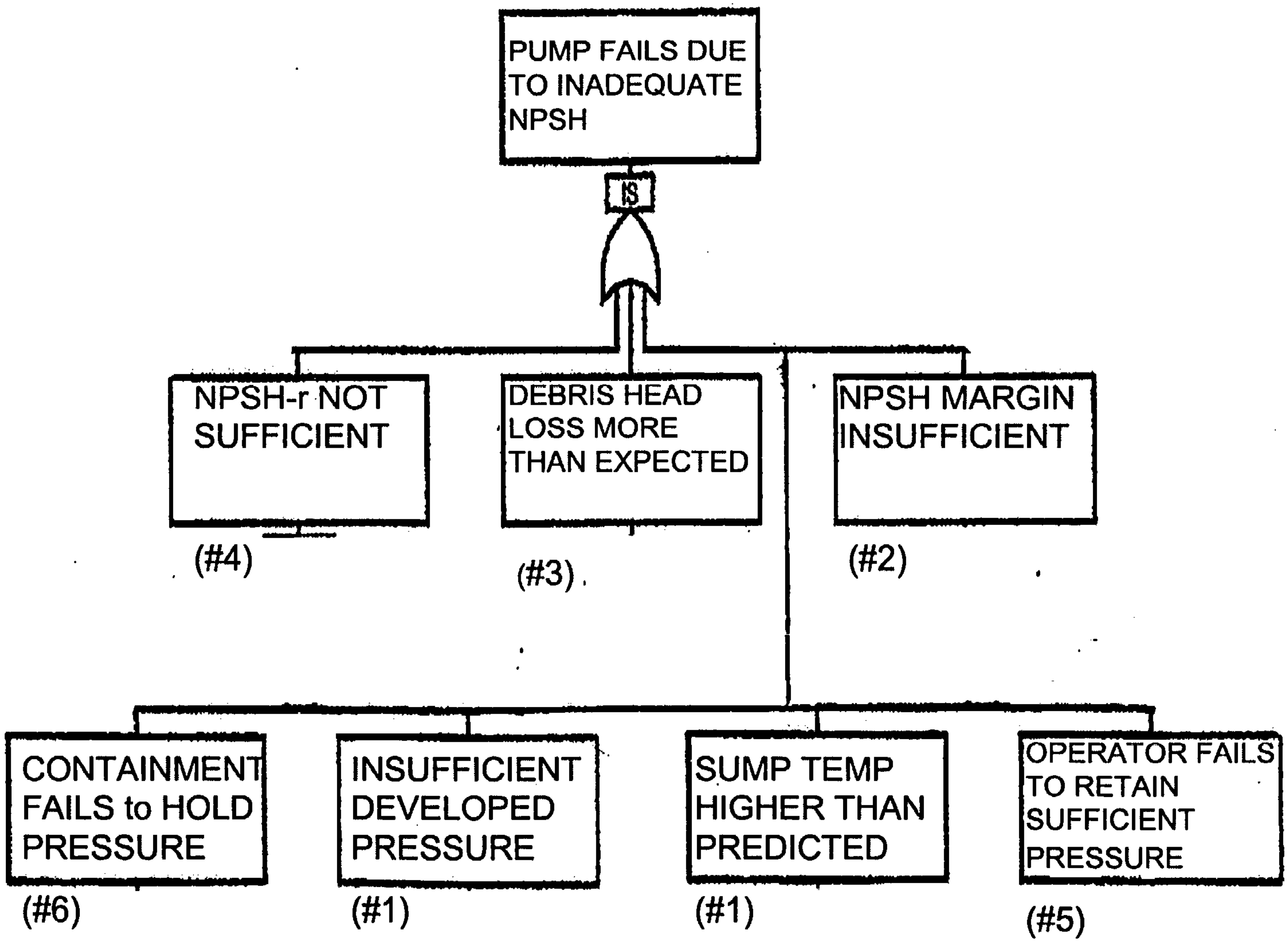
LCS PUMP FAILS TO RUN DURING MISSION TIME

→currently

8.11 E-04

Statement from Ref. Plant IPE

- "LCS pump unavailability due to insufficient NPSH caused by elevated suppression pool temperature is considered in the applicable event tree analysis and is not included in the fault tree model."


PUMP FAILS DUE TO INADEQUATE NPSH
IS
NPSH-r NOT SUFFICIENT
(#4)
DEBRIS HEAD LOSS MORE THAN EXPECTED
(#3)
NPSH MARGIN INSUFFICIENT
(#2)
CONTAINMENT FAILS to HOLD PRESSURE
(#6)
INSUFFICIENT DEVELOPED PRESSURE
(#1)
SUMP TEMP HIGHER THAN PREDICTED
(#1)
OPERATOR FAILS TO RETAIN SUFFICIENT PRESSURE
(#5)

Flaws in Proposed Draft Rev 4

(p.5) For safety-related pumps in nuclear reactors, quantifying margin is complicated by the fact that design basis calculations are done with conservative rather than realistic assumptions (i.e., the available NPSH is underestimated) so that the NPSH margin at expected conditions following a design basis accident is not accurately determined, but is bounded to some significant but unquantified extent. Therefore, for design basis accidents with acceptably conservative assumptions, margin between the calculated available NPSH and the required NPSH **equal only to the debris head loss is acceptable**.

Flaws in Proposed Draft Rev 4

1. Conservatisms – a double counting

Conservatisms are employed because of uncertainties. The double counting is to take credit for them as the Margin that ANSI/HI 9.6.1-1998 recommends - a desired Margin of at least 1.5.

Flaws in Proposed Draft Rev 4

2. Margin = Debris Head Loss - does not have technical meaning or validity

(For Ref. Plant)

* The Debris loss is 0.33 ft .
* NPSH-r in the Ref. Plant is approx. 32 ft.
* 0.33 ft represents just over 1% margin
* ANSI/HI standard called for 50% margin

Flaws in Proposed Draft Rev 4

3. The RG gives no guidance on the percentage of overpressure which may be credited nor the time overpressure may be credited.

The Ref Plant proposes to credit:

Overpressure of 6.10 psig out of a calculated containment pressure of 7.16 psig to 7.78 psig- (between 78% to 85% of the calculated pressure) - for a period of 8-1/4 hours.

Total overpressure credit period - 55 hours

Containment Overpressure Credit for BWR Extended Power Uprates

Plant	Max Press Credited psig	% Max Calc Pressure psig	Duration Tot Credit hrs
Duane Arnold	5.3 psig	tbd	tbd
Dresden 2 & 3	6.6 psig	tbd	38 hrs
Quad Cities 1 & 2	6.7 psig	tbd	43 hrs
Clinton	0 psig	---	---
Brunswick 1 & 2	5 psig	44%	tbd
Vermont Yankee (Proposed)	6.1 psig	85%	55 hrs

Flaws in Proposed Draft Rev 4

- 4. Sections 1.3.1.2 and 2.1.1.2 concern demonstration of acceptability to operate in cavitation. It's not clear how the staff will treat this.
- 5. It is not clear how this guide will apply to transients other than LOCA's – and specifically ATWS

Summary : I have tried to show -

- That the specifics of the Proposed RG are flawed
- That the concept of the Proposed RG is also flawed
- There remain sufficient uncertainties such that unnecessary overpressure credit should not be granted
- Unwise to abandon defense in depth
- That power uprate plants, as voluntary endeavors, do not need and should not be granted this relief

References:

1. ACRS Letter Jun 17, 1997
2. ACRS Letter Dec 12, 1997
3. VY EPU Feasibility Study, June 28, 2002
4. ACRS Letter May 19, 1999
5. ANSI/HI 9.6.1-1998 Information from Hydraulic Institute webpage
6. *How Much NPSH Does Your Pump Really Require*?, Terry Henshaw, Pumps & Systems, Sept 2001
7. *Checking In* (comments on Henshaw paper), Pumps & Systems, January 2002
8. NPSH Study of [VY] RHR CS Pumps, Sulzer Bingham Pumps, 5/26/28 (Att. 5 of VYC-0808, Rev 8)
9. "MSIV As-Found LLRTs Show an Adverse Trend", VY Document CR-VTY-2004-0918, May 5, 2004

PROPOSED REVISION
TO
REGULATORY GUIDE 1.82 REVISION 3

WATER SOURCES FOR LONG TERM RECIRCULATION COOLING FOLLOWING A LOSS OF COOLANT ACCIDENT

Richard Lobel, NRR
Marty Stutzke, NRR

PURPOSE-1

- TO DISCUSS STAFF REASSESSMENT OF REGULATORY POSITION ON USE OF CONTAINMENT ACCIDENT PRESSURE IN DETERMINING AVAILABLE NPSH
- TO DISCUSS CHANGE OF REGULATORY POSITION IN APPLICATION OF CONTAINMENT ACCIDENT PRESSURE IN DETERMINING AVAILABLE NPSH
- TO CONSULT WITH ACRS AND REQUEST ACRS APPROVAL TO ISSUE PROPOSED REVISION TO REGULATORY GUIDE 1.82 REVISION 3 FOR PUBLIC COMMENT

PURPOSE-2

DOCUMENTS TO BE REVISED :

RG 1.82 REVISION 3,

RG 1.1

STANDARD REVIEW PLAN 6.2.2

NRR RS-001 REVISION 0 (EPU GUIDANCE)

APPLICABILITY

- APPLIES TO ECCS AND CONTAINMENT HEAT REMOVAL PUMPS FOR BWRS AND PWRS

CONTENTS

- INTRODUCTION
- REGULATORY BACKGROUND
- PROPOSED REGULATORY GUIDELINES ON USE OF CONTAINMENT ACCIDENT PRESSURE IN CALCULATING AVAILABLE NPSH
- TECHNICAL AND REGULATORY BASIS
- CONCLUSIONS

TECHNICAL BASIS

CONTAINMENT INTEGRITY

CALCULATION CONSERVATISM

PUMP DESIGN

IMPACT ON EMERGENCY PROCEDURES

RISK CONSIDERATIONS

BACKGROUND-1

REGULATORY GUIDE 1.82 REVISION 0

June 1974

14 Positions on Sump Design

50% Blockage of Sump Screens

REGULATORY GUIDE 1.82 REVISION 1

November 1985

Incorpoprates Findings from USI A-43

Uniform Coverage of Sump Screens by LOCA-generated debris

BACKGROUND-2

REGULATORY GUIDE 1.82 REVISION 2

- **May 1996**
- **Incorporates Guidance Supporting NRC Bulletin 96-03**

REGULATORY GUIDE 1.82 REVISION 3

- November 2003
- Incorporates Guidance Supporting NRC Bulletin 2003-01

BACKGROUND-3

DRAFT REGULATORY GUIDE 1.82 REVISION 4

Revises Guidance on Credit for Containment Accident Pressure in Calculating Available NPSH

Additional Technical Information on Determining a Conservative Available NPSH

Editorial Changes

NRC POSITION

NRC HAS ALLOWED CREDIT FOR CONTAINMENT ACCIDENT PRESSURE IN CALCULATING AVAILABLE NPSH

IF

- ANALYSIS HAS CONSERVATIVELY DEMONSTRATED THAT SUFFICIENT PRESSURE IS AVAILABLE FOR DESIGN BASIS ACCIDENTS, AND
- WHEN EXAMINED FOR BEYOND DESIGN BASIS EVENTS, AN ACCEPTABLE LEVEL OF SAFETY IS STILL MAINTAINED

REGULATORY BACKGROUND

REGULATIONS

THERE IS NO REGULATION PROHIBITING CREDIT FOR ACCIDENT PRESSURE IN DETERMINING AVAILABLE NPSH FOR SAFETY RELATED PUMPS

REGULATORY GUIDE 1.1

REGULATORY GUIDE (RG) 1.1: NET POSITIVE SUCTION HEAD FOR EMERGENCY CORE COOLING AND CONTAINMENT HEAT REMOVAL PUMPS

ISSUED NOVEMBER 1970

POSITION: ADEQUATE NPSH SHOULD BE PROVIDED TO SYSTEM PUMPS ASSUMING THE MAXIMUM EXPECTED TEMPERATURE AND <u>NO INCREASE IN CONTAINMENT PRESSURE</u>

RG 1.1 (CONT)

SOME REACTORS CREDITED CONTAINMENT PRESSURE DURING REVIEWS PRIOR TO ISSUANCE OF THIS REGULATORY GUIDE

REACTORS LICENSED AFTER ISSUANCE OF RG 1.1 GENERALLY COMPLIED

USI A-43

GL 85-22 DISCUSSED FINDINGS OF USI A-43:

- BLOCKAGE OF SUMP SCREENS PLANT SPECIFIC
- REVISED SCREEN BLOCKAGE MODEL SHOULD BE APPLIED (UNIFORM COVERAGE OF SCREEN BY DEBRIS)
- RG 1.1 PROVIDES ACCEPTABLE GUIDANCE FOR NPSH CALCULATIONS

GL 85-22 WAS NOT BACKFIT

BULLETIN 96-03

BARSEBÄCK INCIDENT (1992) AND DOMESTIC BWR EVENTS SHOWED FURTHER ACTION NEEDED

BULLETIN 96-03 RECOMMENDED LARGE PASSIVE SUCTION STRAINERS (BWRs)

EVEN WITH LARGER STRAINERS, POSTULATED DEBRIS SOURCE RESULTS IN INADEQUATE NPSH IN SOME PLANTS

CREDIT FOR CONTAINMENT PRESSURE NECESSARY

GL 97-04

CONCERNS RAISED FROM SEVERAL SOURCES ABOUT ADEQUACY OF NPSH CALCULATIONS AND USE OF CONTAINMENT PRESSURE IN CALCULATIONS

GL97-04 ISSUED; ONLY REQUESTED INFO

SOME LICENSEES FOUND NPSH CALCULATIONS INADEQUATE.

WHEN REVISED, CREDIT FOR CONTAINMENT ACCIDENT PRESSURE WAS NEEDED IN SOME CASES

RG 1.82 REV 3-1

- CRITERIA FOR THE REVIEW OF NPSH CALCULATIONS DEVELOPED BY STAFF FOR REVIEW OF GL 97-04 RESPONSES
- CRITERIA NOT PUBLISHED EXCEPT AS APPLICABLE IN INDIVIDUAL SAFETY EVALUATION REPORTS
- CRITERIA INCORPORATED INTO RG 1.82 REV 3 SO THAT ALL GUIDANCE ON EMERGENCY PUMP SUCTION ISSUES IN ONE DOCUMENT

RG 1.82 REV 3 (CONT)

RG 1.82 REV 3 STATES THAT CONTAINMENT ACCIDENT PRESSURE SHOULD ONLY BE CREDITED WHEN:

"*THE DESIGN CANNOT BE PRACTICABLY ALTERED*"

ALSO STATES THAT:

"*NO ADDITIONAL CONTAINMENT PRESSURE SHOULD BE INCLUDED IN THE DETERMINATION OF AVAILABLE NPSH THAN IS NECESSARY TO PRECLUDE PUMP CAVITATION.*"

PROPOSED REVISION-1

STAFF PROPOSES REVISING GUIDANCE TO REMOVE THESE CONDITIONS.

REVIEW POSITION IS:

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 still maintained.

PROPOSED REVISION -2

RG 1.1 NOTE ADDED: RG 1.1 SUPERSEDED BY RG 1.82 REV 4

SRP 6.2.2 WILL REFERENCE RG 1.82 REV 4

NRR RS-001 REV 0 (EPU REVIEW GUIDANCE) WILL BE REVISED AT LATER DATE. WILL REFERENCE RG 1.82 REV 4

THEREFORE: ALL GUIDANCE ON NPSH CONSISTENT

STATUS

PLANTS WITH CREDIT FOR CONTAINMENT ACCIDENT PRESSURE:

16 BWRs (All Mark I containments)

9 PWRs (5 w/subatmospheric containments)*

* SRP 6.2.2 CURRENTLY ALLOWS CREDIT FOR CONTAINMENT PRESSURE DURING THE INJECTION PHASE ONLY

PCT CALCULATIONS

IN PEAK CLADDING TEMPERATURE CALCULATION:

THE CONTAINMENT IS ASSUMED PRESSURIZED DURING PWR REFLOODING, FOLLOWING A LOCA

THE CALCULATED PRESSURE IS MINIMIZED ACCORDING TO GUIDANCE IN: SRP SECTION 6.2.1.5, "MINIMUM CONTAINMENT PRESSURE ANALYSIS FOR EMERGENCY CORE COOLING SYSTEM PERFORMANCE CAPABILITY STUDIES"

TECHNICAL AND REGULATORY JUSTIFICATION

TECHNICAL BASIS

CONSIDERATIONS FOR ACCEPTABILITY OF CREDITING CONTAINMENT PRESSURE:

- HIGH CONFIDENCE IN CONTAINMENT INTEGRITY
- CONSERVATIVE CALCULATIONS
- DESIGN OF EMERGENCY PUMPS
- NO SIGNIFICANT IMPACT ON EMERGENCY OPERATING PROCEDURES
- MINIMAL IMPACT ON PLANT RISK

CONTAINMENT-1

RG 1.1: ONE RATIONALE FOR NOT CREDITING CONTAINMENT PRESSURE IS THE POSSIBILITY OF "IMPAIRED CONTAINMENT INTEGRITY"

- STRUCTURAL INTEGRITY TEST PRIOR TO LICENSING
- 10 CFR 50.54(O) AND APP J REQUIRE LEAK TESTING OF CONTAINMENT AND INDIVIDUAL PENETRATIONS

CONTAINMENT-2

MAJORITY OF PLANTS WITH CREDIT FOR CONTAINMENT PRESSURE HAVE BWR MARK I CONTAINMENTS

10 CFR 50.44 (AND THEIR TS) REQUIRE MARK I CONTAINMENTS TO BE INERTED WITH N_2

BWR MARK I PLANTS ARE REQUIRED TO HAVE O_2 MONITORS

A PROBLEM MAINTAINING INERTED ATMOSPHERE WOULD REQUIRE ENTERING PLANT ABNORMAL PROCEDURES

CONTAINMENT-3

5 PWRs CREDITING CONTAINMENT PRESSURE HAVE SUBATMOSPHERIC CONTAINMENTS

TS REQUIRE CONTAINMENT PRESSURE LESS THAN ATMOSPHERIC PRESSURE

LOSS OF VACUUM REQUIRES SHUTDOWN WITHIN ONE HOUR (TS)

CONTAINMENT-4

CREDITING CONTAINMENT PRESSURE DOES NOT ADD A NEW CONTAINMENT SAFETY FUNCTION.

CREDIT IS TAKEN FOR THE PRESSURE PREDICTED TO BE PRESENT

NOTHING IS DONE OPERATIONALLY TO ENHANCE OR DECREASE THE PRESSURE BECAUSE CREDIT IS TAKEN IN NPSH CALCULATIONS.

NO EQUIPMENT ADDED OR REMOVED

CONSERVATISM

CREDIT FOR CONTAINMENT ACCIDENT PRESSURE IN MANY CASES IS A RESULT OF CONSERVATIVE NATURE OF CALCULATION ASSUMPTIONS

BWR CONSERVATISM-1

- Reactor power is 102%
- Decay heat is at $+2\sigma$ level
- Decay heat based on operation bounding specific cycles
- Worst single failure occurs
- Initial drywell and wetwell temperatures, pressures and relative humidities selected to minimize accident pressure
- Initial suppression pool temperature is the TS maximum

BWR CONSERVATISM-2

- Initial service water temperature is at maximum technical specification value
- Heat transfer between the secondary containment and the torus is ignored
- The initial suppression pool water volume is the minimum allowed by the technical specifications in order to maximize the suppression pool temperature increase. The lower suppression pool level also provides less positive head to the available NPSH and results in a lower calculated pressure

BWR CONSERVATISM-3

- Containment sprays are available to cool the containment. They are initiated at 600 seconds and operate continuously with no throttling of the RHR pumps below rated flow. Spray operation actually would be expected to start before this time. Spray flow could be throttled, as necessary.
- Passive heat sinks are modeled to reduce containment pressure
- Feedwater flow into the vessel continues until all feedwater which would increase the suppression pool temperature is added.

BWR CONSERVATISM-4

- All core spray and RHR pumps have 100% of the brake horsepower rating (rather than water horsepower) converted to pump heat which is added to the suppression pool water.
- The efficiency of heat transfer between the drywell air space and the liquid break flow is chosen to minimize the containment pressure
- A single value of suppression pool level is chosen for the available NPSH calculation that is less than the calculated value at time of peak suppression pool temperature

BWR CONSERVATISM-5

- The pump flow used in NPSH calculation is greater than flow assumed in LOCA PCT calculations. Pump flow never throttled.
- The required NPSH is measured with cold water. No correction is made for reduction in required NPSH with temperature.
- Calculation of debris head loss is bounding
- Containment leaks at ≥ La
- Service water flow through the heat exchanger is minimized

BWR CONSERVATISM-6

- Minimum number of ECCS pumps used to inject into reactor vessel

- RHR heat exchanger's effectiveness is minimized by assuming design basis fouling and tube plugging

BWR CONSERVATISM-7

- Debris on strainer for short term analyses (< 10 minutes) is the amount on the strainers at 10 minutes. The remaining debris in the suppression pool and any debris deposited on an active strainer supplying pumps in the short term that is subsequently secured for the long term is deposited on the active strainers in proportion to their flow rates. The total debris thus deposited is used to determine the long term NPSH margin at the peak suppression pool temperature.
- The debris on the suction strainer is assumed to be at a temperaure below the peak suppression pool temperature and to be uniform over the entire flow area. These assumptions result in a higher than expected head loss.

PWR CONSERVATISM-1

- Reactor power is 102%
- Decay heat is at +2σ level
- Decay heat based on operation bounding specific cycles
- Worst single failure occurs
- Initial containment temperature, pressure and relative humidity selected to minimize accident pressure and maximize emergency sump water temperature

PWR CONSERVATISM-2

- Containment volume is maximized

- The refueling water storage tank initial temperature is its maximum technical specification value

- The refueling water storage tank level is at its minimum technical specification value

- The pressure of the containment atmosphere is equal to the vapor pressure of the sump water at the sump water temperature.

PWR CONSERVATISM-3

- All containment cooling systems (containment sprays and containment fan coolers) are in operation at design conditions to reduce containment pressure

- The worst possible pipe break occurs (provides most energy to the sump water).

- The distribution of energy released with the assumed break is distributed in containment in such a way that the sump temperature is maximized and the containment pressure is minimized

PWR CONSERVATISM-4

- The sump recirculation switchover setpoint (RWST level) is at its maximum

- The low pressure injection and containment spray heat exchangers are at their minimum effectiveness (maximum aging effect and tube plugging)

- The service water (ultimate heat sink temperature) is at its technical specification maximum value

PWR CONSERVATISM-5

- Not accounting for required NPSH temperature correction factor

- Conservatively long time for emergency service water flow to reach the low pressure injection and containment spray heat exchangers

- Sump water temperature away from the surface will be below the corresponding temperature at the surface because some heat will transfer out through the bottom of the containment and through piping on the way to the pumps. Not considered.

PWR CONSERVATISM-6

- Containment flood level is underestimated or no credit taken for level of water above containment sump

- The debris bed on the suction strainer is assumed to be uniform over the entire flow area.

- The refueling water storage tank level is at its minimum technical specification value

CONSERVATISM

- A MAJOR CONSERVATIVE ASSUMPTION IS THAT ALL THE PREVIOUS ASSUMPTIONS OCCUR SIMULTANEOUSLY, i.e.,

  break that yields the most adverse NPSH conditions + parameters specified in TS are all simultaneously at worst conditions + worst single failure + every physical process takes place in the most limiting way

STATISTICAL METHOD

A POSSIBLE SOLUTION:

NOMINAL CALCULATION. A STATISTICAL ESTIMATE OF THE UNCERTAINTY IS ADDED TO THIS VALUE.

THE PROPOSED CRITERION IN THE REVISION TO RG 1.82 REVISION 3 STATES THAT THE AVAILABLE NPSH MUST EXCEED THE REQUIRED NPSH WITH A 95% PROBABILITY WITH A 95% CONFIDENCE.

PUMP DESIGN-1

ALL PUMPS OF INTEREST SHARE CERTAIN CHARACTERISTICS WITH RESPECT TO CAVITATION:

- LOW SPECIFIC SPEED
- SUCTION SPECIFIC SPEED SLIGHTLY ABOVE THE LOW ENERGY REGION
- ROBUST CONSTRUCTION
- MECHANICAL SEALS
- STAINLESS STEEL IMPELLERS

RELATIVE RESISTANCE OF DIFFERENT MATERIALS TO CAVITATION*

* John H Doolin, Judge Relative Cavitation Peril With Aid of These Eight Factors, Power, October 1986

IMPELLER MATERIAL	RELATIVE EROSION RATE
Mild Steel	8
Brass	7
Cast Iron	6
Monel	4
Stainless Steel	2
Bronze	2
Titanium	1.4
Aluminum Bronze	1

PUMP DESIGN-3

- SUPPRESSION POOL AND SUMPS WILL CONTAIN HIGH TEMPERATURE WATER AT TIME OF INTEREST.
- THEREFORE, THE GAS CONTENT OF THE WATER SHOULD BE RELATIVELY LOW.

BWR CHRONOLOGY OF NPSHR-1

CONTAINMENT	CP ISSUED	PUMP	NPSHR (FT)	CREDIT
MARK I	1/31/68	RHR	26	NO
MARK I	5/10/67	RHR	24	YES
		CS	27	YES
MARK I	6/4/68	RHR	27.62	YES
		CS	17.05	YES
MARK II	3/9/73	RHR	14	NO
		LPCS	13	NO
MARK II	11/2/73	RHR	7	NO
		CS	11	NO
MARK II	6/19/74	RHR	6	NO
		CS	10	NO
MARK III	9/4/74	RHR	2	NO
		LPCS	2	NO
MARK I	11/4/74	RHR	4.5	NO
		CS	10	NO

CAVITATION CREDIT

THE STAFF HAS APPROVED PUMP OPERATION UNDER CAVITATION BELOW NPSHR

- WITH OR WITHOUT CREDIT FOR CONTAINMENT ACCIDENT PRESSURE
- BASED ON PUMP CAVITATION TESTING

EXPERIENCE

PLANT	PUMP TESTED	TEST SUMMARY
Beaver Valley	recirc spray	1/2 hour. No signs of wear
Quad Cities/Dresden	RHR	3 one hr cavitation tests
		No damage. Minor scratches
Browns Ferry	RHR	Tests in situ
		No damage
Crystal River	Cont Spray	NPSHR acceptable at 5%
Vermont Yankee	Core Spray	<3% NPSHR. No damage
	RHR	< 3% NPSHR. No damage

IMPACT ON OPERATION-1

OPERATOR INDICATION OF CAVITATION:

- ERRATIC OR DECREASING PUMP MOTOR CURRENT
- ERRATIC FLOW OR FLOW LESS THAN EXPECTED
- FREQUENT ADJUSTMENTS TO THE ECCS SYSTEM DISCHARGE VALVE TO MAINTAIN A CONSTANT FLOW RATE

IMPACT ON OPERATION-2

<u>OPERATOR ACTION IN RESPONSE TO CAVITATION</u>

- THROTTLE PUMP
- REMOVE PUMP FROM SERVICE
- CONSIDER OTHER WATER SOURCES

EFFECT OF THROTTLING

RHR/CS	RHR Flow/Pump	Suction Loss (ft)	NPSHR (ft)	NPSH Margin (ft)
4/2	5000	10.7	30	-11.1
4/2	3750	6.5	25.5	-0.7
4/2	2500	3.4	25	4.3

IMPACT ON OPERATION-3

- RG 1.1 CITES CONCERN THAT SPRAYS MAY DEPRESSURIZE CONTAINMENT BELOW PRESSURE NEEDED FOR ADEQUATE NPSHA
- EOPs CURRENTLY CONTAIN INSTRUCTIONS TO TERMINATE SPRAY FLOW TO MAINTAIN CONTAINMENT STRUCTURAL INTEGRITY
- SOME PLANTS HAVE AUTOMATIC SPRAY TERMINATION
- SPRAY TERMINATION PRESSURE IN EOPs CHANGED FOR ADEQUATE NPSHA
- OPERATOR ACTIONS REMAIN THE SAME

Risk Considerations

BWR EVENTS

EVENT	HI SP TEMP	DEBRIS	PRESS CREDIT
LOCA	YES	YES	YES
ATWS	YES	YES*	YES
APP R FIRE	YES	NO	NO
STATION BLACKOUT	YES	NO	NO
ROD EJECTION	YES	YES	NO
INTERFACING SYS LOCA	NO	NO	NO
INVENTORY LOSS (SHUTDWN)	YES	NO	NO
SPURIOUS S/RV OPENING	YES	YES*	NO

PWR EVENTS

EVENT	HI SUMP TEMP/RECIRC	DEBRIS	PRESS CRED>
LOCA	YES/YES	YES	YES
MSLB	YES/NO*	NO	NO
SGTR	NO/NO	NO	NO
ATWS	YES/NO	YES	NO
SBO	NO/NO	NO	NO
ROD EJECT	YES/NO	YES	NO
IS LOCA	NO/NO	NO	NO
RHR LOSS (SHUTDWN)	NO/NO	NO	NO
SPURIOUS SAFETY VALVE OPEN	YES/NO	YES	NO

PRAS: NPSH LOSS

- WASH-1400 (BWR)
- IPEs (discussed in NUREG-1560)
- ASME PRA Standard
- Risk Assessment Standardization Project (RASP) Handbook

DISCUSSION: WASH 1400

- BWR event tree considered containment leakage following a LOCA
- If leakage > 100% per day and long-term cooling fails, ECCS pumps cavitate
- 100% per day = one-inch equivalent diameter hole
- Failure probabilities
  - -2E-5 (small LOCAs)
  - -5E-3 (large LOCAs, drywell, rupture of reactor building cooling water pipes as a result of the LOCA)
  - -3E-4 (large LOCAs, wetwell)

LOSS OF DHR

PLANT TYPE	TOTAL CDF	LOSS OF DHR	CONTRIBUTION
BWR 1/2/3	2E-05	5E-06	5% TO 75%
BWR 3/4	2E-05	2E-06	UP TO 30%
BWR 5/6	2E-05	3E-06	UP TO 30%

PRA MODEL GUIDANCE

- ASME PRA Standard supporting requirements address NPSH
  - -AS-B3: phenomenological conditions
  - -SY-B9: containment failure effects on system operations
  - -SY-B15: environmental qualifications
- RASP Handbook (practical, "how to" handbook of methods, best practices, examples, tips and precautions for SPAR models)

OBSERVATIONS

- Loss of NPSH addressed for BWRs; unimportant for most PWRs due to ECCS pump design
- Currently, PRA modeling only considers loss of NPSH related to containment venting (operator error) following loss of suppression pool cooling
- So far, unable to identify a PRA that explicitly considers loss of NPSH due to failure of containment overpressure
- To date, license amendment requests to credit containment overpressure were not risk-informed

PRESSURE CREDIT-1

- At the staff's request, the licensee of a BWR Mark-I containment made best-estimate MAAP calculations
  - -4.16 ft^2 recirculation loop suction break
  - -MSIVs closed
  - -continued operation of MFW
  - -no credit for containment overpressure
  - -suppression pool cooling not initiated at time t=0
- Results indicate that it takes over 4 hours to cause loss of NPSH due to suppression pool heatup

PRESSURE CREDIT-2

- Initiation of suppression pool cooling can be accomplished in less than 1 minute
  - -simple task done in the control room
  - -proceduralized action
  - -"routine" action; well practiced
- THERP (NUREG/CR-1278) initial screening model for diagnosis within 4 hours
  - -median HEP = 5E-4
  - -error factor of 30
  - -mean probability of diagnosis error = 4E-3

PRESSURE CREDIT-3

- Loss of containment integrity: approximate using failure of primary containment isolation (including undetected pre-existing leaks)
- Failure probability of 6E-3, per fault tree analysis from the IPE
- LLOCA frequency of 3E-5/y (SPAR model)

PRESSURE CREDIT-4

- CDF = (3E-5/y)(6E-3)(4E-3) = 7E-10y < 1E-6/y
- Using the RG 1.174 risk acceptance guidelines, this is a very small risk increase

DEFENSE IN DEPTH-1

- The change does not result in a significant increase in the existing challenges to the integrity of barriers: YES
  - crediting containment overpressure does not introduce new initiators

DEFENSE IN DEPTH-2

- The proposal does not significantly change the failure probability of any individual barrier: YES
  - -previous example indicates very small *CDF, so insignificant change in the failure probability of the first barrier
  - -no impact on the reactor coolant system integrity, so no change in the failure probability of the second barrier
  - -no impact on containment integrity, so no change in the failure probability of the third barrier

DEFENSE IN DEPTH-3

- The proposal does not introduce new or additional failure dependencies among barriers that significantly increase the likelihood of failure compared to the existing conditions: YES
  - -crediting containment overpressure does introduce dependency between the first barrier (fuel clad) and the third barrier (containment)
  - -previous example indicates very small CDF, so insignificant increase in the likelihood of failure as compared to existing conditions

DEFENSE IN DEPTH-4

- The overall redundancy and diversity among the barriers is sufficient to ensure compatibility with the risk acceptance guidelines: YES
  - -previous example indicates very small CDF per the RG 1.174 risk acceptance guidelines

RISK INSIGHTS

- No indication that PRAs have considered loss of NPSH due to inadequate containment overpressure
- Scoping risk evaluation of the overpressure credit indicates a very small risk increase
- Scoping risk evaluation did not identify any special circumstances that rebut the presumption of adequate protection provided by meeting the deterministic requirements and regulations

CONCLUSIONS

CONCLUSIONS-1

- RISK OF CREDITING CONTAINMENT PRESSURE FOR NPSH IS NEGLIGIBLE
- HIGH CONFIDENCE IN CONTAINMENT INTEGRITY
- NO CHANGE TO OPERATOR ACTIONS IS REQUIRED
- FOR SOME PLANTS, RELIANCE ON CONTAINMENT PRESSURE IS THE RESULT OF (OVER) CONSERVATIVE ANALYSIS

CONCLUSIONS-2

- PUMPS HAVE BEEN CAVITATION-TESTED FOR SHORT TIME PERIODS WITH NO DAMAGE
- NEED FOR CREDIT FOR CONTAINMENT PRESSURE FOR BWRs APPEARS LIMITED TO OLDER PLANTS WITH HIGH REQUIRED NPSH