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Thermal Hydraulics Subcommittee

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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THERMAL HYDRAULICS SUBCOMMITTEE

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THURSDAY

OCTOBER 20, 2022

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The Subcommittee met via Video Teleconference, at 9:30 a.m. EDT, Jose March-Leuba, Chairman, presiding.

COMMITTEE MEMBERS:

JOSE MARCH-LEUBA, Chair

RONALD G. BALLINGER, Member

CHARLES H. BROWN, JR., Member

VESNA DIMITRIJEVIC, Member

GREGORY HALNON, Member

DAVID PETTI, Member

JOY L. REMPE, Member

MATTHEW SUNSERI, Member

ACRS CONSULTANT:

DENNIS BLEY

STEPHEN SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

KENT HOWARD

ALSO PRESENT:

PAUL KLEIN, NRR

AHSAN SALLMAN, NRR

STEVE SMITH, NRR

JIM STECKEL, RES

P R O C E E D I N G S

9:30 a.m.

CHAIR MARCH-LEUBA: The meeting will now come to order. This is a meeting of the ACRS Thermal Hydraulics Subcommittee. I am Jose March-Leuba, the Subcommittee Chairman. This meeting is being conducted remotely via MS Teams.

I see the following ACRS members in attendance, Ron Ballinger, Charles Brown, Greg Halnon, Dave Petti, Joy Rempe, and Matt Sunseri. We also note that our consultants, Dennis Bley and Steve Schultz, are present.

Today's topic is Revision 5 of Regulatory Guide 1.82, Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Cooling Accident. This Reg Guide describes an approach to meet requirements for water sources available for emergency core cooling and other safety systems, like containment cooling. This revision of the guide was issued in final form in August 2022.

Let me give you a short introduction on the history of this topic from my personal point of view to remind the members of our past interactions with the staff. Most relevant point is that this provides guidelines for evaluating the adequacy and

the availability of water sources for long-term recirculation cooling following a LOCA. It includes the issues of the regeneration and the use of containment accident pressure. ACRS has been involved with both issues over a long time with multiple meetings and letters. We have reviewed the containment issue as part of the resolution of GS-191 and wrote letters agreeing with the staff approach, including actual plant implementations.

On the issue of containment accident pressure, or CAP, we wrote three letters in 2009, '10, and '11 and concluded that credit for CAP should be allowed only if plan modifications are not practical and the use should be limited in amount and duration, and it should include a risk assessment. We also recommended that the guide, Revision 3 in 2009, should be modified to recommend the type of analysis that the staff will expect to credit CAP use. In my opinion, Revision 5 implements our second recommendation, but high-level disagreements may remain, especially on the need for risk analysis. Members should keep this in mind while we are reviewing it today because it is a critical issue that will affect our letter.

Finally, even though it is not part of the guide, I have asked the staff to give us their

perspective on the defense-in-depth that FLEX equipment would provide in these type of accidents. This is not part of our guide review, but this provides useful information since (audio interference). We are expected to have a full committee meeting on this topic and likely write a letter on November 1st. We expect that this meeting will be conducted entirely over this public line. Portions of our meeting may be closed to the public to protect proprietary information, if necessary. If we go to a closed line, we will have an opportunity for public comments before we start the closed session of the meeting.

The ACRS was established by a statute that is governed by the Federal Advisory Committee Act, FACA. As such, the Committee can only speak with published letter reports. The ACRS section of the U.S. NRC public website provides our charter, bylaws, agendas, letter reports, full transcripts for the open portions of all full or subcommittee meetings, including the slides presented there.

The Designated Federal Official today is Kent Howard.

A transcript of the meeting is being kept. Therefore, speak into the microphones clearly and

state your name for the benefit of the court reporter. Please keep the microphone on mute when not in use and minimize the use of video feed to avoid bandwidth problems for people assessing the meeting remotely.

At this point, I will give the floor to the staff to commence their presentation. Jim, can you go ahead.

MEMBER REMPE: Hey, Jose?

CHAIR MARCH-LEUBA: Hold on. Yes, Joy?

MEMBER REMPE: I'm sorry. Maybe it's just my connection, but sometimes you cut in and out, and I guess I don't know if other people have that problem but I could not hear where you said in my opinion the Reg Guide. Could you repeat what you said? Because I --

CHAIR MARCH-LEUBA: Let find that part because I have it written.

MR. BLEY: While he's looking, I don't know --

(Simultaneous speaking.)

CHAIR MARCH-LEUBA: Do you have --

MEMBER REMPE: No, it's me, not someone else. But would you repeat it for my own benefit because I think that's an important statement I'd like to hear.

CHAIR MARCH-LEUBA: Yes. For the benefit of everybody, let's see, let me change my --

(Simultaneous speaking.)

MEMBER REMPE: -- said he was fine, so it may be just me, but just repeat it for me, please.

CHAIR MARCH-LEUBA: Do I sound better now?

MEMBER PETTI: Way better, Jose. Yes, you sounded like you were on the end of a long line.

CHAIR MARCH-LEUBA: Okay. So what I said is, I'm repeating now, in my opinion, Revision 5 implements our second recommendation, that being that they have to document the type of analysis that the staff expects to review to credit CAP use, but high-level disagreements may remain, especially on the need for a risk analysis.

MEMBER REMPE: Thank you very much.

CHAIR MARCH-LEUBA: So, basically, there were two recommendations. One is whatever the staff expects from an applicant to take credit for CAP, they need to document it, and that's what Appendix B of the Revision 5 is. But we also had a recommendation that maybe we do some risk analysis with this modification.

Okay. Any more comments before we move to

the staff? No? Jim, staff, go ahead.

MR. STECKEL: Thank you, Jose. I'm going to briefly open the camera just so you have an idea who you're speaking with. I'm going to introduce myself and the two technical leads responsible for the revision of this Reg Guide 1.82.

My name is Jim Steckel, and I'm a Program Manager in the Office of Research, Division of Engineering, and was designated to be the project manager on this particular revision. Ahsan Sallman, a Senior Nuclear Engineer with NRR DSS, is one of the revision engineers that worked on this particular upgrade to the Reg Guide; and Mr. Steve Smith, Senior Plant Systems Engineer, also with NRR DSS.

I'm going to briefly describe what we're going to present to you today. We are going to talk about the main changes in Rev 5, and these include the following. GSI-191. This issue constitutes the main body of the Reg Guide and Appendix A. The next item is containment accident pressure, CAP. There will be a brief CAP description and how it is accounted for in Appendix B. Also to be discussed is how this revision provides some background on the relation of Reg Guide 1.81, Revision 5, to GSI-191, including a summary of the GSI-191 issue, changes made in Reg Guide 1.82 for

GSI-191, and Reg Guide 1.82 status with respect to GSI-191.

Additionally, we'll touch on Revision 5 public comment resolutions. And, finally, we'll discuss the role of FLEX equipment regarding defense-in-depth.

I would now like to turn over the screen to Steve Smith. Thank you.

MR. SMITH: Okay. We're just rearranging here so that we can be in front of the camera and control the screen. I guess we'll turn the camera off to save bandwidth, as you recommended.

I'm going to try to go to the next slide.

CHAIR MARCH-LEUBA: We can see it.

MR. SMITH: There we go. All right. I'm going to turn my, I'll turn the camera off here so you pay more attention to the slides.

Okay. So this is slide two. We have the presentation split up into two parts. I'm Steve Smith, and I'm going to talk about the main body of the Reg Guide and Appendix A. Those two we had relatively minor changes to just to update references and add some information about GSI-191 things.

Ahsan is going to talk about Appendix B, which is a new appendix for containment accident

pressure, or CAP. It's just easier to say CAP, so we're going to say CAP. I will also talk about the public comments. We just did a very high-level summary of that, and then we have a couple of slides that also talk about how FLEX could provide defense-in-depth for these two issues.

This slide just provides a brief description of the technical changes and the applicability for Appendix B, and you'll see more about that later on. So I'm going to move on to slide three. If you have any questions at any time, just go ahead and let me know and I'll stop and try to answer.

All right. So this is slide three, and I'm going to be just providing a brief background on GSI-191. This slide shows a few of the additions we made to the Reg Guide and, in parentheses, we have the approximate times that the NRC staff positions were developed or items were published. So some of these have some items published or letters sent, you know, providing guidance to the industry.

All right. The next few slides, slides four through seven, this might not make any sense, but this is a brief long history. This slide shows the pre-GSI-191 highlights. I'm not going to spend a lot of time sitting on any of these slides, so I'm just

going to let you guys take a look through it and if you have any questions. On this slide, this is everything that occurred -- not everything. This is a lot of the things that are related to the GSI-191 issue that occurred prior to the time that GSI-191 was initiated.

The next slide shows the initial NRC actions with respect to GSI-191. So it was actually initiated in 1996, and then, starting in 2003, we sent out a bulletin. In 2004, we sent out the General Letter 0402, which is still ongoing. The GSI remained open for a long time because some of the technical issues were not fully understood, and we'll talk about that a little bit on the next slide.

This slide, slide six, is the more recent GSI history, and the things that really slowed the closure down were chemical effects and in-vessel effects were not well understood when we sent the issue out to industry for resolution. Chemical effects methodology was relatively quickly resolved, and we had an acceptable method in 2007. But the in-vessel effects methodology was really not accepted by the NRC staff until 2019. And chemical effects do interrelate with in-vessel effects, so there was some interplay there, too.

But, anyway, for stringers, the chemical effects were figured out by 2007, and then in 2019 we figured out how to resolve in-vessel effects and we put some guidance out for that.

Once we understood -- yes?

MR. BLEY: This is Dennis Bley. I've been working my brain trying to remember some of this history as it went on. Wasn't it during the chemical effects investigations that we had some contradictory experiments that took some time to get worked out? I don't quite remember how that was settled.

MR. SMITH: I'll tell you what, I'm hoping that Paul Klein is on the line, and he might be able to help us out with that because he's our chemical effects expert. Are you on, Paul?

MR. KLEIN: Yes, Steve, I'm on. This is Paul Klein. So I guess a very short summary of how the chemical effects evaluation happened, as Steve mentioned, we understood early on after initial testing that chemical effects could be a problem, but there really wasn't a very good understanding of timing with respect to chemical effects. So that took quite a bit of time to really fully understand timing. We knew that, if chemical effects occurred, it could cause very large head losses.

And so the contradictory testing that I think you're referring to is some of the early in-vessel tests where they added the pre-mixed precipitate. The actual head loss that was incurred by chemical effects was really dependent upon the particulate and fiber bed that had formed at the inlet to the fuel. So I think that, over time, the particulate-to-fiber ratio, when the composition of the bed at the fuel inlet became better understood and, more importantly, the timing became understood. And then as alternate fuel paths were evaluated, it became clear that, for most plants, in-vessel chemical effects would not occur until after the point where there was sufficient alternate water paths into the vessel.

MR. BLEY: Thanks. That helps.

MR. SMITH: All right. Thank you, Paul. So the last thing, as we sort of just discussed, the last thing that was not resolved for GSI-191 was the understanding of in-vessel effects. Once we provided a guidance for how to resolve the in-vessel effects, GSI-191 was closed because all the technical issues were well enough understood to make that happen.

However, plants that have not responded adequately to Generic Letter 0402 are still required

to respond. And on the next slide, I have a summary of what the status is for all the plants. This is slide seven coming up.

Okay. So this shows the status of the plants. At the top are the deterministic plants, and at the bottom is where we stand with risk-informed resolution. So we had nine low-fiber plants that closed out using the original in-vessel guidance, which was probably at least ten years before the final in-vessel guidance. And then we had ten plants close out deterministically after we released the 2019 guidance. We have seven plants that have deterministic submittals under review and two plants we haven't received their final in-vessel submittals yet.

And then we have six plants that are using a risk-informed resolution. Two plants are closed. South Texas was the first one, and Vogtle was the second one. And those were -- STP did not use the new in-vessel guidance, but Vogtle did. And you guys looked at both of those large or safety evaluations that we wrote. We have two plants under review, and we have two plants that are planning on sending risk-informed license amendment requests in.

Okay. Slide eight, we're going to shift

gears a little bit. This just shows some of the things that we changed or added to the Reg Guide. The first thing is we added a reference to the draft Reg Guide 1.229 for risk-informed evaluation. This is what licensees have been using, that draft Reg Guide, when they submit risk-informed LARs to us.

And then we also did a BWR evaluation of lessons learned. Since the BWRs closed many years ago, we've learned quite a few things, and they did a lot of work and NRC staff did a lot of evaluation to ensure that they had adequately addressed the major areas.

On slide nine, this shows the changes that were made. This is the biggest changes to in-vessel downstream effects, so we did the safety-significant technical evaluation report, which the ACRS looked at. And we also developed the review guidance for the same issue. And I just tried to put the important references here.

One of the other important references is on slide ten, and that is the WCAP-17788, which is -- was a large body of work that industry did to help us understand the issue. And then back on slide three, there was a few other things that we added. I didn't put the numbers down for those, but we added

references to cover those, as well.

On slide 11, this is kind of a wrap-up as far as GSI-191 and Reg Guide 1.82. We expect this revision to be basically inclusive of all our guidance for GSI-191. We understand that, you know, we may learn a few things in the future and we might make some minor changes, but this is basically the last revision we're going to make to the Reg Guide for this issue.

The other thing that's kind of important is the rulemaking 10 CFR 50.46(c) is still with the Commission. And so that may get, that may change the way that we do risk-informed LARs. The only thing is this rulemaking has taken such a long time that we think we'll have all the risk-informed LARs probably done before the rule is actually implemented. So kind of depending on how that rulemaking goes, we'll decide what to do with the draft Reg Guide 1.229 on the risk-informed evaluation of the issue. Now --

MR. SCHULTZ: Steve, this is Steve Schultz. Before you go on, so the Reg Guide right now is still a draft guide?

MR. SMITH: Yes, 1.229 is still draft.

MR. SCHULTZ: Still a draft guide. And right now there is no further work that is ongoing,

and it will depend upon what the Commission determines with regard to the rulemaking.

MR. SMITH: We didn't think it was appropriate to finalize that Reg Guide because it is, it's right now connected to the rulemaking. So we didn't want to finalize or go any further with that draft Reg Guide until the rulemaking is complete.

MR. SCHULTZ: The risk-informed submittals you've already reviewed and they're coming in are using the draft?

MR. SMITH: They are using the draft, yes.

MR. SCHULTZ: Good. Thank you.

MR. SMITH: Okay. So at this point, I am pretty much done with the GSI-191 part of this. I have slides on public comments and then how FLEX provides, can provide defense-in-depth for the issue. It's up to you whether we do those now, or we can do them at the end if that seems more appropriate. Whatever you guys, the ACRS Committee members think would be the best thing to do. I can either go through those now, or we can wait until after the CAP presentation.

CHAIR MARCH-LEUBA: I think you're on a roll. Let's keep going. You're doing well. Just continue on this. It makes sense to finish this.

You're doing well.

MR. SMITH: Okay, all right. So we're going on to slide 12, and this is just these public comments. We didn't go into a lot of detail here. We didn't receive a ton of public comments. We received four sets of public comments from three entities, and I list the areas here. They were basically applicability and scope definitions, clarifications, and references, and add risk-informed guidance. And for these, we made changes where we thought it was appropriate.

We didn't think that Rev 5 was intended to cover new reactors, except where the guidance would be applicable to them. There was some comments that thought that we should make it clear that this was not applicable to new reactors, and that wasn't the intent of this revision. Maybe the next revision will be more specific with that, but we didn't do any work to try to make this applicable to new reactors. So we just expect them to use the guidance if it's applicable.

And then we made some minor changes just for clarifications and references, and we did not add risk-informed guidance. We're awaiting the 50.46(c) rulemaking. That was one of the comments. And I

think we have a couple more.

On the next slide, slide 13, there were some comments that said we should be more specific with the methodology, and the NRC thought that the methodology was adequately specified. We did change some references to make them public so that, you know, people could look at those. And, basically, editorial comments we incorporated.

Okay. We're going to move on to talk about FLEX a little bit in slide 14. Okay. Now, the thing about the FLEX is we are not FLEX experts. So we talked to some people who worked on, we got input from them to help create these slides. What we figured out is BWRs have direct RCS injection points that include high-volume flow, and those injection points are predetermined and set up so they can just take the FLEX equipment and pick it up and it will inject to the RCS.

PWRs have some low-volume RCS flow and high-volume steam generator flow. So if there was a LOCA, and it was a large LOCA, they don't have pre-existing connection points to provide high-volume flow to the RCS. They have, you know, they could provide probably tens of gallons.

So the guys we talked to who reviewed this

for the BWRs and PWRs, they said that they could reconfigure, plants could probably reconfigure the steam generator pumps to inject to the RCS, but it's not pre-set-up. It would take time, and it's kind of a plant-dependent thing. So it depends how the plant is designed and how their FLEX equipment is designed as to how easy it would be to do that.

So with that in mind, we can go through the next couple of slides. I kind of went through slide 14 there, and then this slide 15 provides just, slide 15 talks about strainer blockage, and it's relatively similar. We looked at relatively similarly to CAP blockage or CAP, you know, if you've lost containment accident pressure, which is shown on the next slide.

But, anyway, for most strainer blockage events, the pressure in RCS would be low. BWRs would have no problem hooking up FLEX capacity. So we look at BWRs as having pretty good defense-in-depth. And as we discussed on the previous slide, the PWR FLEX strategies may be less effective for long-term cooling. The PWR injection to the RCS is on the order of tens of GPM, but that does include boron, you know. They would have borated water to inject. Those are designed for pump seal leakage usually or shutdown

conditions where you'd have a very low requirement for volume of flow.

So, generally, it seems to us that BWRs have better defense-in-depth, then probably pretty good defense-in-depth, and the PWR would not have as readily available defense-in-depth. It might take, you know, depending on how long it takes the plant to hook a higher-volume pump up, that would be important as far as defense-in-depth is available. Eventually, they could get there, but it might take, you know, we don't know how long it would take.

CHAIR MARCH-LEUBA: So this is Jose. I ask you to think about this area, even if it's not part of the Reg Guide. When we go visit the plant, we see this beautiful FLEX equipment, and we wonder if it's useful. And what I'm hearing is, and I'm jumping to Appendix B at the CAP credit, if we give CAP credit to a boiling water reactor and some additional accident loses the pressure in the containment by cooling it or venting it or whatever mechanism, FLEX would provide some defense-in-depth and probably it would not be cause of the accident in boilers.

MR. SMITH: That's correct. Slide 16 was more focused on the CAP credit issue, although, you know, the way that the FLEX equipment works is similar

for both. So we concluded that the BWRs would be more likely to use FLEX equipment to provide RCS injection, in the case of a loss of NPSH, would include both the loss of CAP or a clogged strainer. And PWRs would have challenges to do that because they'd have to take time to hook up the larger volume pumps to the RCS.

MEMBER BALLINGER: This is Ron Ballinger. I think we need to be a little bit careful since we're on the record of using the words defense-in-depth. I think what you're saying is that the FLEX equipment may or may not augment existing defense-in-depth. You're not saying that we don't have defense-in-depth and the FLEX equipment doesn't help. So I think we need to be a little bit careful of when we use the word defense-in-depth in this context.

CHAIR MARCH-LEUBA: I think you're wrong. The way I read it, I understand it, is it provides additional defense-in-depth.

MEMBER BALLINGER: Right, right. That's what I'm saying. We need to be careful about the words and be careful that somebody doesn't read this at some point and say, oh, my gosh, what do you mean they don't have defense-in-depth.

CHAIR MARCH-LEUBA: Well, the reason why I was asking this is to do a risk analysis in our

minds of if you lose your CAP and suddenly your pumps just start cavitating, what do you do? And what I'm seeing from the analysis the staff performed is, in boiling water reactors, you just run to the FLEX building and bring those pumps in, and you're out of the problems.

MEMBER BALLINGER: Right.

CHAIR MARCH-LEUBA: In PWRs, you have to think a little more. It's good to have them, but they're not designed to plug in in five minutes.

MEMBER BALLINGER: Right. But you're not starting from a zero defense-in-depth point.

CHAIR MARCH-LEUBA: Correct. And we'll talk about it a little more on CAP, but my understanding is it's more challenging for boiling water reactors than for pressurized water reactors.

Okay. Staff, continue.

MR. SMITH: If I just go back, if you go back to slide 14, that provides a little bit more background. We say on there the FLEX strategies are not, they're not designed for the events that we're talking about now. They're for beyond design basis external events that come from natural phenomena. They're not for LOCAs or events that would be likely to end us up using containment accident pressure.

So this is exactly what the FLEX guides were saying. We do need to be careful how we characterize this. This equipment is not designed for this kind of accident. However, it can provide some mitigative capacity, and it seems like BWRs would have better mitigative capacity than PWRs.

MR. BLEY: Yes, this is Dennis Bley. I want to go back to what Ron was saying, and I guess the main defense-in-depth here is the containment, which ought not lose its pressure. And that's where the old arguments were hanging about just a small amount and not for long. And then we had an applicant come in that was proposing what seemed like a large amount for a very long time, and then you start worrying about could something happen to the containment.

So the fact that FLEX, which Steve said is designed for something else, can be very helpful here is common with a lot of places people have found they can use FLEX that gives us really a backup for things that we thought very good anyway. So, yes, I'm agreeing with Ron and I think Jose fell in the same position. We're pretty well okay here, and FLEX can really help if you need it, which is very unlikely. That's enough.

MR. SMITH: Yes, I agree. I think, yes, it's not part of the design basis, which is, you know, what we're trying to do with this other thing. It's just something additional that could be available.

So that was my last slide. I'm going to turn it over to Ahsan unless there's other questions.

CHAIR MARCH-LEUBA: I think that's a good plan.

MR. SMITH: Okay.

CHAIR MARCH-LEUBA: So we're moving now to containment accident pressure.

MR. SMITH: Yes. Just rearranging the room here. Be with you in a second.

MR. SALLMAN: This is Ahsan Sallman. I'm in the Nuclear Performance Branch in DSS, and I'll talk about the guidance for the use of the containment accident pressure for the net positive suction head margin for ECCS and containment heat removal pumps in BWRs and PWRs.

So this is the contents showing, this slide shows the contents with the topical background, ECCS, the role of ECCS pumps, and the regulatory requirements, use of CAP in NPSH margin, cavitation, erosion, effect of non-condensables, gas, loss of containment isolation, containment cooling if CAP is

used, illustration of the CAP available quantifying margin, the guidance summary. And then I have a list of acronyms and symbols if anybody wants to look at this at the end of this presentation.

This slide shows the CAP issue. CAP is used in determining the NPSH available for ECCS and containment heat removal pumps, and this was highly criticized by the ACRS during maybe 15 - 20 years ago when there were a couple of LARs from Browns Ferry and Monticello, which, because of the CAP issue, they were using CAP and the review was, you have to hold or suspend it because of this. Then at that time we requested BWR Owner's Group to submit a topical report, which is NEDC-33347, and the BWR Owner's Group developed a standard approach for requesting CAP.

Then staff wrote a white paper, and that documented the staff position for the CAP, usage of CAP. And then we had some ACRS letters that were written to EDO and showed what is a position of ACRS, and that is, I've written them down here, CAP credit should be limited in amount and duration, and the operator reactions, if the control CAP should be reliable.

The next slide is ACRS wanted SRP-622, which is on the containment heat removal, to be

revised and include the risk information in the CAP. And the ones that are on star (phonetic) -- these recommendations of ACRS were incorporated in this Reg Guide, like modification of the plant before we give CAP credit and we show that it is practical or impractical.

And then this report, Owner's Group report which provided a standard approach for use of CAP, the statistical method of calculating the uncertainty in that BSH. So then other suggestions or other recommendations from ACRS was a hardware modification or risk studies would not be needed if CAP credit is small in deterministic analysis.

Okay. There was an ACRS letter that was written to the Commission chairman about a disagreement between the ACRS and staff, and the ACRS position was a CAP should be, the CAP credit should show the deterministic analysis, as well as plant-specific PRA, that should be included. And the staff position was not for the deterministic, not for the PRA but only the deterministic analysis.

At that same time, staff requested a pump consultant to give us the different -- on different tasks, there were four tasks assigned to the pump consultant, and these tasks are written down here in

this slide.

The next slide is --

CHAIR MARCH-LEUBA: Go back and let's understand --

MR. SALLMAN: Yes, sir.

CHAIR MARCH-LEUBA: That 2011 letter is our last, well, last position I know of. What the staff is saying that, if you created CAP in your analysis and you show your NPSH is acceptable, you don't need to do anything else, you can take credit for the CAP. And the ACRS position was that, for a short time and if you don't use too much of your CAP margin, that is certainly okay; but, if you want to do it for more than a hundred hours, then maintaining the containment pressurized involves a number of events, like operator errors of omission or commission; additional failures of containment, if you had a big seismic event that necessitated the whole thing.

So is that your position, and this is the position in the Reg Guide now that --

MR. SALLMAN: Yes. The Reg Guide position is now that you do the deterministic analysis using CAP. And if CAP is used -- then I'll go over that in the new few slides. If the CAP is used, which is above the vapor pressure at the suppression of the

pool temperature, then that has to be, there should be additional analysis which was recommended in this BWR Owner's Group report, and that is what we do the Monte Carlo analysis to show how much margin it is. And that was what was recommended by the ACRS at that time.

CHAIR MARCH-LEUBA: Yes. But after you do an LAR, for example if you want to do a power operate, and now you need a CAP credit --

MR. SALLMAN: Yes.

CHAIR MARCH-LEUBA: -- need before, are the operators required to update the PRA with the consequences of creating CAP? I mean, there should be a branch on the PRA, a number of sequences that include failure of containment after having the accident where CAP is needed, and they're not required to evaluate that?

MR. SALLMAN: Well, that is not in the Reg Guide at this time because -- I'll go to the next slide, what happened when the Commission paper was submitted, the SECY paper was submitted to the Commission, and then they worded on the Commission paper, SECY paper, and that determined that there was no plant-specific PRA required and only the deterministic analysis with some recommendation that

are in this slide from the ACRS that are included in the guidance.

CHAIR MARCH-LEUBA: From a technical point of view and a logical point of view, I'm making a change to my plan, just, for example, a power operate, that requires me now to credit CAP for my ECCS pumps to work as advertised, and they have to operate for an amount of time, X hours. I would like to know what is the condition of probability that the containment pressure would remain high for those X hours and consider if allowing operation for those six hours introduces an additional risk. And my gut feeling is, if we do the analysis, it would come out to be irrelevant, I mean, very small. But we don't do the analysis, the probabilistic analysis.

MR. SALLMAN: No, it is not in the guidance.

CHAIR MARCH-LEUBA: Yes, I know. Okay. Thank you.

MEMBER DIMITRIJEVIC: This is Vesna. I just want to tell you, based on my experience, if you can credit CAP, that's not part of the PRA model. You don't ask that, so you just assume the pump will operate with no issue with the NPSH. So I have not seen, based on my experience, that, but I did not

really have a, I didn't really look at the latest that CAP shows as, that probabilistic CAP shows as input in the PRA model.

CHAIR MARCH-LEUBA: Yes, that is what I was saying. The Reg Guide 1.82, that's not required, and apparently nothing else requires it. And logically, I mean, if we are going to be a modern risk-informed regulator, we should know what the risk is.

MEMBER DIMITRIJEVIC: Remember the PRA cover only injection for 44 hours after accident, I mean, except for containment performance, which is sometimes asked for 72 hours. But the coolant plant in that period is only 24 hours.

CHAIR MARCH-LEUBA: The CAP credit for preventing NPSH is a short duration. I mean, it's maybe 24 hours, right, Ahsan? What is typically the time that you need a credit?

MR. SALLMAN: Well, we submitted this guidance in the form of an interim guidance to the owner's groups and we received some LARs on EPUs that were reviewed by the staff and the ACRS. And following this guidance, some of them, they did not use CAP. They improved their plant, one of them, they improved their plant. But mostly, in Appendix R

analysis for the fire, Browns Ferry was using several hours of CAP; I don't remember exactly how much, but that was an issue when this whole thing started in 2007 - 2009 and that review was suspended.

But the duration was, in Appendix R analysis, they used maybe more than 50 hours or something.

CHAIR MARCH-LEUBA: Yes, 50 hours --

MR. SALLMAN: I'm not sure whether the number, but it was a very high number.

CHAIR MARCH-LEUBA: Yes, 50 hours is not a very high number to keep the, when you're talking about containment integrity, in my opinion. If you have to --

MEMBER REMPE: Well, just --

(Simultaneous speaking.)

CHAIR MARCH-LEUBA: -- that would be --

MEMBER REMPE: But to give some more background.

CHAIR MARCH-LEUBA: Yes. Okay. Dennis --

MEMBER REMPE: But to give some more background, Browns Ferry got rid of their CAP credit before they got --

MR. SALLMAN: Yes, that is correct. They got rid of the CAP credit by improving the heat

exchanger performance parameter, the K value of the heat exchanger, and so did Peach Bottom. They got rid of the CAP by putting a cross tie between the two loops of the RHR heat exchanger. And some of the BWRs are using CAP, but the CAP is less than the vapor pressure at the sump temperature, and that is allowed in the guidance. So I'll go over that in the next few slides.

CHAIR MARCH-LEUBA: Just a moment. Dennis has a comment.

MR. BLEY: Yes, I just wanted to weigh in a little here. Back when all this was going on, and I forget the exact number for Browns Ferry, but they were out there a pretty long time needing the CAP credit. The staff, Marty Stutzke, presented kind of a generic back-of-the-envelope look at the risk, which showed it was quite low. And I think most of the members agreed with that but thought that it was important to take that look on a plant-specific basis to make sure there wasn't something in a particular plant that would be challenging, and that's kind of where the argument ended.

MR. SCHULTZ: Dennis, this is Steve, and Ahsan, as well. The point that you've just made about addressing the issue on a plant-specific basis is

important, and, as you were speaking about resolution, Ahsan, one of the ACRS's, their comments was that, rather than to use CAP credit, plants should investigate and see if there were changes that could be made to the plant design that would either eliminate or lower the need, reduce the need for CAP credit in the event of an accident.

MR. SALLMAN: Yes, that is correct. This guidance is included that they should look at a plant modification before they take credit, and they should say that this is, they should tell us that this is impractical to modify the plant, and then we can allow them the CAP credit. That was one of the recommendations from ACRS also and the staff.

MR. SCHULTZ: I appreciate your listing of the number of elements that were provided by the ACRS to the staff, and, obviously, there were several discussions associated with it, and you've provided a good indication of what the staff had agreed to with regard to the ACRS recommendation and had implemented in the going forward processes.

MR. SALLMAN: Right. Those are in the, the asterisks in this, on slide 20 show those ones that were included in the guidance. Okay.

So I'll go to the next slide now, I guess,

which is still the SECY paper that was written by the staff gave two options. One was the staff approach to use a deterministic to calculate uncertainty in margins, and the option two was the ACRS recommendation to use the staff approach plus a plant-specific PRA. So the Commission voted for option one. Then the SECY paper was approved, SECY-11-0014, with option one.

So now there's the Reg Guide, Rev 5, Appendix B, that we are presenting here is based on the SECY paper enclosure one. Enclosure one is this subject of the CAP.

Okay. This slide is just showing what the definitions of NPSH, available NPSH, and the CAP. So I'll go to the next one. Okay. Here is the definition of required NPSH which the vendor is supposed to provide, and that definition, according to the Hydraulic Institute Standard 14.6, and that is NPSH results in cavitation sufficient to reduce the pump total dynamic head by three percent. And the figure shows at different flow rates the drop in the dynamic head, and that's where the NPSH is. And the NPSH margin is defined, we defined it as available minus the required, and the required is what is given to us by the vendor.

I'll go to the next slide. And then there's another term that we use here, NPSH margin ratio, and that is a ratio of the available to the required NPSH.

Okay. In the BWRs, the two systems, RHR system and the low-pressure coolant injection -- I'm sorry -- the low-pressure based system, these are the ones that are the main systems, they're pumps. They draw water from the suppression pool and spray the vessel by the LPCS and the RHR is LPCI injection, the low-pressure coolant injection, drawing water from the suppression pool. So when the suppression pool gets higher in temperature, that's when its vapor pressure increases and that's when the CAP is requested. In the PWRs, the safety injection pumps in the recirculation mode of the PWR and also the containment spray cooling for efficient products removal and cooling of the containment. So those are the pumps that mainly require CAP for the NPSH.

CHAIR MARCH-LEUBA: Ahsan, in the analysis, containment spraying has two effects. It removes contamination, of course, but it helps cool the containment and gives you additional NPSH and the sump conditions margin.

MR. SALLMAN: Exactly. That's because

NPSH is, the available NPSH is a transient thing, and that keeps on changing as the transient goes on.

CHAIR MARCH-LEUBA: So if you turn on the spray, there is a race. You know, on the one side, you start lowering the pressure of the CAP, lowering the pressure in containment. On the other side, you also increase your margin.

MR. SALLMAN: Yes.

CHAIR MARCH-LEUBA: So the calculation from the Reg Guide procedures requires you to do the calculation properly for --

MR. SALLMAN: Yes, yes. The calculation of the containment, calculation consists of the suppression pool or the sump temperature conservative calculation of the suppression pool with conservative inputs and also for the PWRs the sump calculation, sump temperature calculation, which are transients. So based on those temperatures of the sump temperature or the suppression pool temperatures, the NPSH is calculated, the available NPSH is calculated.

CHAIR MARCH-LEUBA: Yes. But my point, maybe I'm not really properly -- containment spray is likely to be an operator action.

MR. SALLMAN: Yes.

CHAIR MARCH-LEUBA: Which will happen at

random times. The procedure will tell you one thing, and the actual human factors engineer will tell you something else. And I see it's a difficult calculation because you're likely to reduce the pressure of containment faster than you will reduce the temperature of the sump.

MR. SALLMAN: Yes. When they do the analysis for the containment cooling or the suppression pool cooling, they follow whatever the procedure is, and the safety analysis is based on -- like for BWRs, there's ten minutes allowed for the operator action to switch from the LPCI mode to the containment, to the suppression pool cooling mode. So that is an operator action, and the PWRs, PWRs, mainly, it is at the sump recirculation mode when the containment sprays are initiated. So that is, more or less, several minutes, I think, maybe a half an hour, after a LOCA, a large-break LOCA initiation. So there's plenty of operator refinement; and if they follow the procedures for the containment spray, that's how the calculation analysis is done.

CHAIR MARCH-LEUBA: Okay. Thank you.

MR. SALLMAN: The recirculation is, you know, in the BWR, it is more critical, the operator action is more critical because it's only -- but the

PWRs, there's a lot of time before the sump flow is initiated.

Okay. Go to the next slide. The regulatory requirements are GDC 35, which is for the safety, for the RHR LPCI injection, and the GDC 38 is the containment heat removal for both, and that is RHR pump on the containment spray pumps.

The guidance initially was also included, some of the guidance was included in the Reg Guide 1.82 before this revision, and that is in this section which I've noted here, 131, which requires conservative calculation for the transients and for a typical test for crediting containment operation and cavitation, calculation of the pump water temperature and head loss in the suction strainer.

Okay. The uncertainty analysis and the NPSH margin, that was a recommendation also from the ACRS following the BWR Owner's Group topical report, which provided us with a Monte Carlo calculation to calculate the margin, and that was also recommended. And then special, for special events, which is, in the BWRs, it's station blackout event and Appendix R fire event and an adverse event. Those three events are the special events in which it was cited and agreed upon that the realistic, instead of conservative

calculation, realistic inputs or nominal inputs can be used.

CHAIR MARCH-LEUBA: And this is consistent with how we analyze special events.

MR. SALLMAN: Right.

CHAIR MARCH-LEUBA: For all the other analyses we do.

MR. SALLMAN: Right.

CHAIR MARCH-LEUBA: Nothing unusual about it.

MR. SALLMAN: Right. So the use of CAP in the -- okay. The NPSHR three percent, that is the basis for the vendor testing. I think that is provided by the vendor, and the NPSH margin, it was recommended that we should include, in the margin we should include the uncertainties because the pump is tested in the factory and the field NPSH required may be different. So that was one of the recommendations also from the ACRS that we should include the uncertainties and then compare the available with the required, and that is called NPSHR effective, which includes uncertainties because of the situations, different situation in the testing. Testing may be done with a different model speed or a different configuration of the test setup, or it could be the

air content in the -- so that is given in the next slide. I'll talk about that also.

Pump speed is one of the factors that would affect the difference. Water temperature, the water temperature which is different at the factory -- the water temperature was recommended not to be considered because if there's an increase in the water temperature at the site, that means that NPSHR would go down. So that was not included in this guidance.

The third one is a suction, the suction piping configuration, which is different. So that is another uncertainty. And the last one is the air content in the water, which may be different at the site.

So all these uncertainty values were evaluated by the staff with a pump consultant. He gave us the guidance on how to use these uncertainties.

So it was decided and it was also recommended by the ACRS to use the NPSHR effective, which includes uncertainties in the NPSH for the DBA LOCA. And for the special events, for the BWR special events, station blackout and Appendix R events, you can use the three percent which is provided by the site.

The ones that we reviewed, some of the EPUs that were reviewed, they decided to use 21 percent uncertainty, which is the pump consultant gave us a bounding value of that. And the guidance says either, you know, the plant licensee should come up with a justification of the uncertainty, and they decided to use what was suggested by the pump consultant. That is in his report, 21 percent.

Okay. This slide shows if there's a negative NPSH margin then it should be, then the test should demonstrate that the pump will perform its safety function. Operation for a limited duration, less than a hundred hours. And if the test is done on the actual pump or a similar model and the testing at the same speed, so, in that case, if it is properly tested using these recommendations, then the guidance says that, yes, you can use negative margin.

CHAIR MARCH-LEUBA: Could you explain a little? Go back to Slide 14.

MR. SALLMAN: Okay.

CHAIR MARCH-LEUBA: Negative NPSH margin, even after applying the CAP? What do you mean by negative margin?

MR. SALLMAN: Negative means NPSHa is less than NPSHr.

CHAIR MARCH-LEUBA: With or without the CAP credit?

MR. SALLMAN: For DBA -- for DBA, it has to be effective. Effective means uncertainty.

CHAIR MARCH-LEUBA: Yes.

MR. SALLMAN: If you use that -- if you use that credit, so you use NPSH effective, and you use CAP credit, and then that -- that means that you have applied certainties and you compared NPSH -- availability of the NPSH required. So that's how you come to the NPSH margin or the DBA.

And, similarly, for the special events, you subtract available minus the fee percent NPSH.

CHAIR MARCH-LEUBA: So --

MR. SALLMAN: If there is a negative margin -- if there is a negative margin in such cases, I think which is very rare, you know, we haven't seen such thing, but the guidance allows that, and then it -- the pump is tested for these conditions.

CHAIR MARCH-LEUBA: So they're testing, running the pumps with an NPSH negative.

MR. SALLMAN: Yes.

CHAIR MARCH-LEUBA: And it -- eventually, the pump destroys itself. But for the first 100 hours, available to operate in a slightly

different mode, but not --

MR. SALLMAN: Well, I don't know if this test has been done, but we are saying that this -- this is -- this is required to be tested if -- if the licensee say we're going to operate a negative margin. Okay. Then let's do this test.

CHAIR MARCH-LEUBA: Okay. But nobody is really --

MR. SALLMAN: No. No, yeah. Yeah.

CHAIR MARCH-LEUBA: Yeah.

MR. SALLMAN: This is in the guidance.

CHAIR MARCH-LEUBA: Okay.

MR. BLEY: Can I -- can I jump in? This is Dennis Bley again. I think for me -- and I kind of think for most of the members at the time -- the staff's pump consultant's reports were really enlightening. At least for me, with an operating background, I always thought you're losing -- loss of suction head, you're done; the pump is gone.

But there is the idea that, you know, two things that are happening. The pump, as you begin to lose it and go negative, you -- and start cavitating slightly, you lose pump efficiency, but you also start doing damage. And there is a pretty extensive time period before you really destroy the pump.

So it was a very interesting set of reports that they brought forward.

MR. SALLMAN: Yeah. You know, I have -- I have a backup slide on that. What erosion damage would be done to the pump, it would be thousands of hours I guess, I think it mentioned in this report. That the erosion damage, because of the cavitation and negative NPSH, pump operation could take -- take that while operating several -- several hours, several -- I think it has been closing for thousands of hours.

MEMBER HALNON: Yeah. This is Greg. Those low-pressure injection pumps and PWRs are very, very robust. Matter of fact, I think they are repurposed from old paper slurry, slur plants that they use. So they are very resistant to any kind of major or quick erosion or cavitation problems.

MR. SALLMAN: Okay. We'll go to the next slide. So this slide is presenting on the cavitation erosion, insufficient NPSH margin resulting in pitting of the propeller blade and other pump parts due to condensation caused by the vapor bubble implosion.

So the recent study, the acoustical measurements experience shows maximum erosion rate after the NPSHa value, which is between three percent and the cavitation's inception margin ratio of four.

So this -- this slide shows the erosion zone and cavitation, non-cavitating zone, the three percent head drop curve.

CHAIR MARCH-LEUBA: So what was the story of this slide and the previous discussion is that there is no sharp edge at which you hit it, the pump blows up, because it -- vibrating so much it kills itself. It's a slow erosion, a slow degeneration, so you can have cavitation for 100 hours for pumps and it still survive.

MR. SALLMAN: Yeah. Even more than that, the pump consultant report, it was -- and I can open that backup slide if you want me to.

CHAIR MARCH-LEUBA: No need. I think I hear what you're trying to say, that we always to think you cavitate, your pump is just vibrating, and it falls to the ground. And it's not the case. It just has some erosion, has some vibration, has some degrading, and eventually it will fail. But they are very strong pumps.

MR. SALLMAN: Yeah.

CHAIR MARCH-LEUBA: Thank you.

MEMBER DIMITRIJEVIC: This is Vesna. I just want to make a comment that at this time, I mean, you hopefully recover your suction, because once you

fail those pumps, doesn't matter how many hours. You are doomed. You don't have any more means to cool the reactor, because those are your RHR pumps in the PWR.

So it doesn't matter, the last 1,000 hours we have to recover section before they fail. I mean, this is just my comment in this case, because those -- all the pumps you have available to cool the plant down, you know, after you are shutdown. So --

CHAIR MARCH-LEUBA: I agree, Vesna. But typically this loss of NPSH is important. Eventually, you are going to cool down your suppression pool and recover your NPSH, of course using these pumps. So, the better one.

MEMBER DIMITRIJEVIC: Right.

MR. SALLMAN: Yeah. The number of hours that -- that these pump operate for the safety-related operation, that is -- you know, during those hours, even if there is minor degradation taking place in a pump, nothing will happen to the pump. That was from the report, consultant's report.

Okay. Go to the next slide.

Effect of non-condensable gas on mechanical performance. That -- that is also one of the points that the pump consultant mentioned that the -- that's why for -- for the entrained air from the

suction source vortices or release pump solution can affect the pump performance.

So the configuration of the PWR pump or BWR suppression pool should consider eliminating entrainment of air by spraying the vortices. These are all guidance in there -- in this.

The last one is the time of operation in the region of maximum relationship be limited.

Okay. This is one of the items that was included in the guidance that if -- to demonstrate the loss of containment isolation and containment leakage. So if CAP is used, the licensee should demonstrate that there is no preexisting leak in the containment.

And one of the -- one of the licensees -- I think Monticello -- they used CAP for I think Appendix R analysis or the DBA LOCA also. They were required to monitor the containment during plant operation for preexisting leak. And this is how they were monitoring, and that is also in the guidance.

In the EPU report that they gave us, they included that -- that we will monitor the containment during plant operation for a preexisting leak.

Another thing is, the licensee should demonstrate sprays and coolers will not reduce the needed CAP. Operator reaction to control CAP by

spraying a pool is acceptable, justified, and operating procedures should include proper guidance for operator action.

Go to the next slide.

CHAIR MARCH-LEUBA: Hold on. This is Jose. Go back to there. The guide mentions -- I don't know about which section -- that the risk for -- that the time -- that limiting the time at which you can operate with CAP credit is not risk significant, because the risk is controlled by preexisting leaks in the containment, like this containment isolation, loss of containment isolation, that you are talking about at the time of the accident.

And the additional risk of the containment development a risk -- a leak during the CAP credit operation is very small.

Do you care to expand on that? I mean, is this what you're saying here? That you mean that raised by monitoring the containment before the accident --

MR. SALLMAN: Yes. That is correct. During plant operation, the licensee was using CAP -- either PWR or BWR -- and be required to monitor an existing leak in the containment.

CHAIR MARCH-LEUBA: Right. But they --

MR. SALLMAN: For that --

CHAIR MARCH-LEUBA: They got -- the recommendation from ACRS was that CAP should only be used for short periods of time, and the rationale behind it in my mind is that you don't want to develop a leak 10 hours after the accident.

But the argument in the guide is that there really -- there should be -- there is no need to put a serious limit on the CAP credit time because if you do a risk analysis, you find out all the risk is controlled by preexisting leaks.

MR. SALLMAN: Right. Right.

CHAIR MARCH-LEUBA: Is that correct?

MR. SALLMAN: So that is correct, that initially it was short period of time. But when we included these uncertainties in the analysis, and tried to see that the plant has -- the NPSHa is compared with NPSHr effective, then we are also doing this containment monitoring prior to the accident, or during plant operation we are monitoring the containment for -- for preexisting leaks.

These are all guidance that are in this -- in this guidance, in this Reg Guide to minimize or to, you know, to -- for acceptable CAP, that the CAP is acceptable, or not just for short period of time but

they can use -- for the amount -- they're not really necessary for the entire cooldown of the containment.

It could be -- some plan may be for short period of time. Some plan may be during long-term cooling. But it's -- it was initially for short period as ACRS recommended. But with this guidance that we have approved, or we have -- we have given to the licensees, this will allow them to use the CAP as needed, but to -- to use the CAP, then, to follow this -- the guidance for the preexisting leak.

CHAIR MARCH-LEUBA: Okay. Thank you. You can continue.

MR. SALLMAN: Thank you. Okay. This is -- this is how the CAP is used, would be used for this curve. This graph represents the containment pressure. ATM is the containment pressure, and this line here represents the atmospheric pressure or the initial pressure in the containment before an accident.

And during an accident, if the -- if the pressure of the suppression pool or the sump goes above -- above the vapor pressure at this -- at the sump -- at the initial temperature, that's the -- this line, HVP, is representing the vapor pressure at the sump temperature or the suppression pool temperature.

So if it is -- if the CAP is requested within -- below this value, below this curve value, the lower curve value, then that is mostly -- that is mostly acceptable because you cannot -- if the temperature in the pool is high, you cannot lose that pressure.

So that is mostly PWRs. There is some temperature goes higher than the 212 degrees, which is atmospheric. So if that temperature -- if the pressure goes -- the temperature goes higher than 212, then the CAP is allowed to be used up to the vapor pressure of the sump temperature.

If they -- if they are requesting CAP above that, above that HVP curve, that means that now they have to follow the guidance, which is a preexisting leak monitoring and whatever is in this guidance. And BWRs, mostly they -- their sump suppression pool temperature scales below 212 degrees during a LOCA, some of them which have notice that goes slightly -- maybe slightly above 212. It's 220 degrees.

And if they -- if they are using CAP, they are asking to use CAP, then for that situation, that's similar to the -- that's going above the HVP -- HVP curve. So that means that they have to follow the

guidance of the preexisting leak, monitoring the preexisting leak.

MR. BLEY: So, Dennis again. The HVP curve --

MR. SALLMAN: Yes.

MR. BLEY: -- essentially we're saying there, since that's arising from the kind of place you end up after everything flashes and you -- you've equilibrated, it would take a pretty big hole in containment to really affect that very much.

MR. SALLMAN: Right. That's true.

MR. BLEY: So there's not much one could -- could challenge on that one. Okay. Go ahead.

MR. SALLMAN: Yeah. So that's how the PWR -- most PWRs that I have reviewed, they stayed below that HVP -- HVP curve, and they are allowed without any preexisting leak monitoring.

Okay. So now this slide is showing how we want to quantify the monitoring for LOCA, perform realistic analysis. Sorry, first they do the bounding conservative analysis for the containment and NPSH, both with bounding inputs, and perform realistic analysis to determine the margin.

If the CAP is used, then in order to show the margin, they are required to do the 95/95 lower

tolerance limit of Monte Carlo calculation to show the margin. This Monte Carlo is only introduced in this guidance in order for them to demonstrate that there is -- there is margin, good margin.

And then for the DBA LOCA, the requirement is that NPSH required -- should include uncertainty. That is, the available must be compared with the required, which is NPSHr effective.

But for the special events, it's only realistic inputs for the NPSH analysis, like the suppression pool or the sump temperature. Doing a realistic analysis is acceptable, nominal inputs, and -- and then NPSHr may be used without uncertainty. That is a three percent provided by the vendor.

So this is how the margin is quantified.

MR. SCHULTZ: Ahsan?

MR. SALLMAN: Yes.

MR. SCHULTZ: This is Steve Schultz. Just on the -- on this slide here where we're talking about addressing these events with realistic analyses plus uncertainty, I'm particularly interested in the BWR special events. Have any of the licensees had difficulties in applying the guidance in terms of demonstrating that the results are favorable?

MR. SALLMAN: Not that I've known so far.

I viewed Monticello, Browns Ferry, Grand Gulf, three of them, and I didn't see any issues with them. I think mostly Browns Ferry got rid of the CAP because they demonstrated their heat exchanger performance was much better, and they were doing the monitoring of the heat exchanger also.

MR. SCHULTZ: Right.

MR. SALLMAN: And they got rid of the CAP, but Monticello used CAP. Monticello is the only plant that I know used CAP for Appendix R and for -- also for DBA LOCA, I believe. I'm not sure, but this is what I remember.

And they -- they did -- they followed this entire guidance.

MR. SCHULTZ: Yes.

MR. SALLMAN: You know, the demonstrated using effective -- NPSHr effective and NPSHa available. And also they introduced the preexisting monitoring of the previous D&D (phonetic). But the special events also in Monticello I remember, only that -- I think Appendix R.

MR. SCHULTZ: Okay. Thank you.

MR. SALLMAN: Yeah. Okay. This slide is the guidance summary, which we have almost discussed all of these things. But I just -- just to repeat

them here in the slide, that NPSH for DBA, it should be compared with NPSHr effective, including the uncertainty, especially when you can use three percent NPSHr effective.

The flow rate that should be used for the NPSHa analysis should be greater than the flow rate used in the safety analysis. That is one important point that is in there.

Loss of containment for venting, sometimes I think procedure maybe -- maybe include venting of the containment, but that should not be done if the CAP is used.

CHAIR MARCH-LEUBA: This is Jose. And that's accomplished via procedures, modifying the EOPs?

MR. SALLMAN: This is one of the requirements in this Reg Guide that if they -- any of the procedures, if they're using CAP and any of the procedures require venting, that should not be the case.

CHAIR MARCH-LEUBA: But venting is in the procedures to protect containment. I mean, you don't vent unless it is absolutely necessary. It's a good thing to say, hey, I want to protect my pumps, so protect my pumps. But if you do it by destroying the

containment --

MR. SALLMAN: That's a severe accident situation, destroying the --

CHAIR MARCH-LEUBA: Yes, it is.

MR. SALLMAN: -- containment. That is not the design basis. In the design basis scenarios, I don't know if there is any plant that would do that, but --

CHAIR MARCH-LEUBA: Not from design basis.

MR. SALLMAN: Not for design -- you're talking about design basis. If any plant has some procedure in which they talk about containment venting, that should not authorize the CAP is used (phonetic). That's one of the points in this guidance.

CHAIR MARCH-LEUBA: Okay. And by CAP -- excuse me. If I --

MEMBER DIMITRIJEVIC: How about containment cooling or containment spray?

MR. SALLMAN: Containment spray is one of the safety -- one of the safety systems which is used, and containments sprays are used. You know, that is a normal thing for -- during a LOCA. I mean --

MEMBER DIMITRIJEVIC: No, no. Of course, but that will cool the containment, and, therefore,

reduce the pressure also.

MR. SALLMAN: Yes. Yeah, of course. Of course.

MEMBER DIMITRIJEVIC: So is that part also -- you said that he monitors the containment pressure. That means, you know, the impacts venting and cooling, right?

MR. SALLMAN: I cannot say cooling. Cooling is -- cooling is a regular item in the containment safety -- you know, the safety analysis. Containment cooling is a part of the safety analysis. While venting --

CHAIR MARCH-LEUBA: What you're trying to say, Ahsan, is that the analysis that determined the CAP credit assumed that sprays were working.

MEMBER DIMITRIJEVIC: Okay. Well, that's exactly --

MR. SALLMAN: See, the CAP credit can be at any time during short term, long term, in the PWRs, in the short term if it is -- well, the short term does not require CAP in PWR, because it is only -- the CAP is only -- would be required when the sump recirculation starts.

That time -- that's -- that time if the CAP is required, it means, you know, the sprays aren't

operating. But one -- if the CAP is required, one should not have a procedure which includes containment venting.

CHAIR MARCH-LEUBA: Okay. And then --

MEMBER DIMITRIJEVIC: So they have included the cooling in the CAP calculation.

MR. SALLMAN: Yeah. The cooling is -- cooling is included in the analysis. The regular -- the safety analysis includes everything, all of the -- all of the systems that come in operation during containment cooling during an accident.

CHAIR MARCH-LEUBA: Yeah. The issue will be, Vesna, the inadvertent actuation of the spray when it's not supposed to.

MEMBER DIMITRIJEVIC: Yeah. But the spray is not -- you know, spray is actuated by the operator. I mean, you know, like, for example, in PWR, if you have a large LOCA and you switch to recirc, let's say, in half hour, that's -- you know, those are all after all -- this is all operator action. So that's what I want to say. This is not something which happened automatically, so it can be controlled by operators.

MR. SALLMAN: Yes, yes. Yeah. The analysis does consider that action, operator action. And that's how the analysis is -- what determines how

much CAP is needed.

MEMBER REMPE: So this Joy.

MR. SALLMAN: Yes.

MEMBER REMPE: I guess I'm still thinking about this loss of containment integrity. Venting shouldn't occur during CAP use. When the Monticello EPU came through, it was around 2013, and we were still reacting to post-Fukushima insights.

And I know our letter -- at least I thought our letter mentioned that as folks were revising the severe accident (audio interference) that that might be an issue. And I don't -- I think we haven't seen anyone else that uses CAP for -- from the BWRs or even -- and help me understand. How will the staff ensure that there isn't any sort of operator guidance that would conflict with what's here?

MR. SALLMAN: Can you repeat what -- the question? Venting -- the regular analysis that we do for safety analysis, based on which we determine the CAP, would not include venting. If the CAP is used, not including venting.

But I -- I am not sure how if you -- if -- when would the venting be opening and --

MEMBER REMPE: Well, there has been an emphasis on early venting. In the revised guidance,

there has been an emphasis on early venting for severe accidents, you know, for prevention and mitigation. And I just am wondering how the staff will ensure that that revised guidance doesn't conflict with this guidance that says we shouldn't have venting.

(Audio interference), others, Jose, do you understand what I'm trying to say?

MR. BLEY: Joy, this is Dennis. Let me cut in. At least for me, you're cutting out. We're missing part of what you're saying. But I think I get your question, and I'll try to repeat it because I think others missed out.

And that is during a severe accident, we have severe accident guidance now that says to vent the containment. But if we got that -- if we have -- we're melting the core, we're beyond our concerns here about CAP. So I don't think -- I don't see how they conflict.

And Joy was worried that that guidance could lead people to vent when they're still trying to maintain CAP. But if you've lost the core, you've lost that game of maintaining CAP, unless I missed what you were getting at, Joy.

MEMBER REMPE: Okay. So I apologize for my connection. And I understand that it is in the

severe guidance that this early venting is (audio interference). So I guess I am looking into timing. I mean, so basically, you're saying all the revised guidance would wait until you really clearly see you've had cladding heat up, and that there is some sort of release before they would say we're going to vent.

And so the timing is carefully monitored, and there is no chance that the operators would vent early and adversely affect this CAP use. And the staff is aware of this (audio interference) emphasizing early venting, and it will not occur at a time -- for example, if you're trying to get rid of hydrogen, and you're having oxidation of the cladding, I just am wondering about, is the timing that precise in that they would be careful that they are not worrying about this long-term cooling capability?

I think you understand where I'm going, Dennis, and --

MR. SALLMAN: Yeah, yeah, I understand. But we are -- we are within the design basis. This guidance does not go into the severe accident scenario. So we are just talking about venting. Is there a design basis accident? And the procedure -- one of the procedures for mitigation of a design basis

accident says, hey, you need to vent the containment.

That is not allowed if the CAP -- if they use CAP, because, you know, then the lose the pressure, and then of course it -- the pump will not operate. But this is within the design basis. So severe accident is a different, you know, area that is --

MR. BLEY: What Joy is -- what Joy is getting at -- and I suspect she has cut out for you folks, too -- is that some of that guidance is trying to jump the gun and save the containment by venting it. And you don't have -- I'm still in the design basis meter on the board. The operators are trying to save the core. But at the same time, they have this guidance saying to get an early jump on venting the containment, and that one needs to be careful that those two sets of guidance don't conflict.

And I -- I think that's a good point, and somebody needs to -- to track that. I don't think it -- I don't know that it goes in your guidance here, but it ought to be somewhere.

MEMBER REMPE: Thank you.

MEMBER HALNON: Yeah, this is Greg.

MEMBER REMPE: Thank you, Dennis. That helps. Thank you for interpreting.

MEMBER HALNON: I think I'm a little confused. We're talking now about an actual event and what the procedures say as opposed to I thought this was to be applied to the analysis that shows you can credit containment pressure.

And I guess I'm confused now. Are we still talking about the rules of a game to do the analysis versus how operators actually respond? I mean, I guess my question is, is this -- if the analysis shows that -- and if you want to credit accident pressure but the analysis shows that at some point you have to vent, then you can't credit the pressure at that point, or you have to change your procedures to prevent venting.

MR. SALLMAN: That is correct, sir. If the analysis is showing that you should not vent the containment, if you want to use a CAP, and if -- if -- then there would be a different analysis. The licensee -- if they say we want to vent the containment during a design basis accident, then that analysis would be a different analysis.

MEMBER HALNON: Right. And if you're going to vent --

MR. SALLMAN: That is not --

MEMBER HALNON: Well, if you're going to

vent outside of your procedures that were part of the analysis, then you're in a -- you're in a position of declaring 50.54X and going outside your procedures because something else is happening.

And as Dennis said, you are probably well beyond the need for a containment pressure credit anyway. So the analysis uses the procedures. The procedures are followed by the operators. And if you have to go outside of those procedures, that's one thing. But if you follow the procedures that you've used in the analysis, then you can credit the containment pressure.

If the procedures are such that you can't -- that you have to vent, then you can't credit containment pressure.

MEMBER REMPE: Right. And I'm trying to say that when somebody applies this analysis, they'd better be careful that their procedures do indeed not allow any sort of venting. Dennis put it well. There is not a -- we're staying in the design basis region here. I just want to make sure that that interface is carefully monitored is what I'm trying to get at.

MEMBER HALNON: I agree, Joy, and that should be part of the analysis and --

MR. SALLMAN: That's what -- this bullet

point is guiding the licensee that there should not be any venting in the procedure if they are using CAP. It's like -- it's like a precaution I guess, or one of the things that the licensee should consider or look at. If they want to use CAP, they should not vent the containment in their procedure. So that should be consistent with the analysis and the procedure.

MEMBER HALNON: But the point I made is that the operator is not during the response to an accident is not -- it's not in his mind whether or not he is crediting containment pressure or not.

MR. SALLMAN: No. But the procedure -- I believe the procedure should be developed based on the analysis.

MEMBER HALNON: That's what I'm saying.

MR. SALLMAN: Yes.

MEMBER HALNON: They have to follow procedures. And if they follow procedures, they should be fine, because --

(Simultaneous speaking.)

MR. SALLMAN: Yes.

MR. SCHULTZ: This is not -- this is not an operator activity statement. This is a go or no-go statement as to whether CAP credit can be used.

MEMBER HALNON: It's built into the

procedural steps.

MR. SALLMAN: Yes.

Okay. The other items in this -- well, in this slide, the likelihood of a preexisting leak, that -- you know, during plant operation they should monitor the containment for a preexisting leak. And negative margin is acceptable, as we discussed about, you know, that testing should be done.

Then the goal of maximum erosion should be between 1.2 and 1.6. That was information that was given to us by the pump consultant.

The topical BWR should follow the topical report, which is -- which was submitted to NRC and also there was an SER in that topical report, which provided Monte Carlo, you know, uncertainty analysis.

For the PWRs, the CAP options are to use the vapor pressure corresponding to the sump, sump water temperature, or use a procedure similar to the Owners' Group, Monte Carlo.

Emission time for the pump using CAP, to include the recovery time from the accident. So these are the guidance -- summary of the guidance, these few bullets.

Okay. This slide is showing what EPU LARs that were reviewed, and I was involved in reviewing

these LARs for the containment only. And the CAP, Monticello, Browns Ferry -- and Monticello was, you know, reactivated. Actually, it was suspended when we started the SECY paper.

And Browns Ferry was also suspended, but they resubmitted their LAR. Then other ones were Peach Bottom. They modified the hardware. Grand Gulf was fine. Turkey Point -- not using Turkey Point 3 and 4. St. Lucie, Point Beach.

All these PWRs, they -- they use the CAP up to the vapor pressure. None of them used both the vapor pressure and the sump pressure.

CHAIR MARCH-LEUBA: So just to understand, all these plans are taken clearly for CAP.

MR. SALLMAN: They're -- no, I'm not saying they're taking CAP. But they followed the guidance. And Monticello is the only one which took credit of the CAP. Browns Ferry, they did some modification of the heat exchanger I think, a monitoring of the heat exchanger.

Peach Bottom is the one that modified the hardware. And when I say modified the hardware, it means they follow -- they follow this guidance, did not use any CAP after they modified the plant.

Grand Gulf did not -- as I remember, did

not use CAP. Turkey Point, St. Lucie, Grand Gulf is a BWR, so they did not use CAP. Turkey Point, St. Lucie, and Point Beach, these plants they use CAP but up to the vapor pressure, which is allowed in the guidance.

So the only plant that I can think about is the Monticello that they used CAP, and they did all the analysis according to this guidance, and they also have a preexisting leak monitoring in the facility.

CHAIR MARCH-LEUBA: Let me see if I can summarize. The use of containment accident pressure credit is not widespread among the fleet. It's only a few plants here and there.

MR. SALLMAN: Well, it is --

CHAIR MARCH-LEUBA: It's allowed.

MR. SALLMAN: Yeah. When it started, Reg. Guide 1.1, which is the Safety Guide 1.1, only allowed -- did not allow to use CAP. But then, at that time, some plants were using some CAP, like, you know, mainly the Browns Ferry and Monticello, they were the one that was using a lot of CAP in the analysis for DBA and Appendix R fire analysis.

And at that time, when they were using a lot of CAP, at that time the whole thing started between ACRS and the staff, and the reviews and then

these, you know, letters were written and the SECY paper was developed.

But later on when we got the revised Browns Ferry LAR, they did not use -- they demonstrated by analysis that they have an improved heat exchanger which did not -- which required -- which has enough performance of the heat exchanger that it is able to cool the suppression pool without using CAP. And the vapor pressure was -- and especially the Browns Ferry Appendix R analysis was using too much -- too much CAP.

CHAIR MARCH-LEUBA: Okay. Thank you. Does any --

MEMBER REMPE: And I think, as I recall, Monticello is a very low power BWR. So it was -- it's a much lower power I guess is something to mention, too, here.

MR. SALLMAN: Yeah.

MR. SCHULTZ: So, Ahsan, what you're saying about Monticello is that they used the guidance, but they didn't have --

MR. SALLMAN: Yes. If you --

MR. SCHULTZ: -- to take credit for CAP.

MR. SALLMAN: Yes. Yeah. This guidance was in the form of an interim guidance that we sent to

the Owners' Group, and that's what they used.

MR. SCHULTZ: Then you mentioned other analyses that -- where CAP credit has been taken. Are all of the ones in the third bullet there EPU LARs?

MR. SALLMAN: Yeah. All of them are EPU.

MR. SCHULTZ: Okay. Thank you.

CHAIR MARCH-LEUBA: So, Ahsan, this ends your presentation?

MR. SALLMAN: Yeah. These are the ones that I reviewed. There was maybe some others which I don't know, somebody else -- the staff may have reviewed. But I don't know the status. But the ones that I put here are the ones that I reviewed.

Yeah. This is the end of the presentation, and if any more questions or any questions, I can try to respond.

CHAIR MARCH-LEUBA: So, members, any questions from the staff or discussion? I hear none.

I am going to --

MR. SCHULTZ: Excuse me. Jose, this is Steve. I had a question for clarification. It was in Steve's presentation where a comment was made that the revised -- Rev 5 is for operating units, and then there was a comment, something about additional guidance could be provided for new reactor

applications. Did I get that right? That this is not -- this is not available for guidance or the guidance would have to be modified for any new reactor applications?

And one reason I'm asking that is, as I saw -- was looking at references for the review, the last -- the last ACRS letter I saw where CAP credit was discussed was for the USA PWR application. And some issues came up in the -- in that review where CAP credit was being supported by the -- by the PRA or there was some suggestion that it could be supported by the PRA.

And the ACRS wrote a letter that suggested that the PRA for the USA PWR was not sufficiently developed to make that determination, and that in the final discussion that an approach that would use best estimate plus uncertainty would be the appropriate way to go.

I'm not sure how that finally got resolved in the approval, but, again, there is a new reactor application, and it came up also in EPR. I was wondering, what is the plan for new reactor applications with regard to CAP credit?

MR. SMITH: Okay. So this is -- this is Steve Smith. I discussed the comments. And basically

for new reactors, we -- or the public comments I should say to make it -- make it clear. I discussed the public comments.

Ahsan may want to jump in and discuss how we would apply this to new reactors.

The reactor designs that you're talking about are similar. Do you -- as far as GSI-191 stuff, these reactors used basically the same guidance that the reactors -- you know, the operating reactors used for strainer and -- strainer testing, strainer issues, and all that.

As far as CAP is concerned, I think we're still -- we're still saying that if this guidance would be applicable to those reactors, which I believe it would be, it should be used.

We were not looking forward to the newer -- you know, we weren't trying to do these reactors that are going to be different. You know, they're going to be, you know, molten salt reactors or that kind of thing. We weren't trying to write the guidance to be applicable to those kind of reactors. But if it's applicable, if these are light-water reactors, there is a good chance that this -- at least some of the guidance that's included in this revision of the Reg Guide is going to be applicable to them.

MR. SCHULTZ: And going back to the public comments, then, there were a number of comments that were made by NuScale. And I -- I think you may want to expand on what you just said because I -- my impression was that NuScale was saying that -- that the guidance should be adjusted because in their designs there is equipment that is described that isn't in the NuScale design.

Could you elaborate on the NuScale comments and how you've responded to those?

MR. SMITH: Right. So for those comments, basically what we said, we -- we have responded relatively generically, and we said that they should look at the guidance. And if it's applicable to their plant design, they should use it.

And our intention with the Revision 5 was not to -- was not to determine which plants it is or is not applicable to. We didn't want to -- we wanted to allow, you know, the staff doing the review and the licensees or the applicants who are designing the plants to determine whether the guidance is applicable to them or not and use it if it is -- you know, if it would be applicable.

MR. SCHULTZ: Good. And then, just to expand on that a little bit, in any case, what the

guidance is saying is that any change or any application that's associated with CAP credit needs to be evaluated on a -- needs to be evaluated by the staff on a plant-specific basis and an application-specific basis.

MR. SALLMAN: Yeah. That's correct. I'm not sure what the new plants, which one required CAP credit. I haven't seen any. But I am expecting that if a new plant comes, I think I -- I have seen some -- some -- for the Korean plant, which was which one, EPR? Yeah, EPR.

Yeah. That one -- that was a PWR, and that was applying CAP credit up to the vapor pressure of the sump pressure. And that's all they needed. They did not go beyond that vapor pressure.

MR. SCHULTZ: That's how it was finally resolved and addressed.

MR. SALLMAN: Yes. Yes, yes, yes. I talked to some of the new reactor staff, and they -- they told me that this is how they use CAP.

CHAIR MARCH-LEUBA: Steve, any more comments?

MR. SCHULTZ: No. That's fine. Thank you.

CHAIR MARCH-LEUBA: Okay. Anybody else

have more discussion or questions for the staff?

Any member of the public has any comments they want to place on the record? If so, please unmute yourself and -- and say it now. I don't see any phone numbers. So if you are on a phone number, you can just star six.

I hear no members of the public wanting to make a comment, so this will end the presentation.

We are now going to talk administrative a little bit. We expect to have a full committee meeting on November 1st, which is a couple weeks from now, and write a letter. And any other members wants to oppose the idea of having a full committee meeting? Because I assume we all say that we should write that letter up. Yes?

I hear no opposition to writing a letter, so we will write a letter on November 1st.

My proposal to the staff is that you provide us a reduced presentation, at most half an hour, during the full committee to give us plenty of time to have discussions, and the committee on the open session and prepare the letter.

So certainly summarize GSI-191 and FLEX, but I am looking for one or two slides each and concentrate on the CAP issues that we have been asking

you about.

And that's it. I am going to start drafting a letter, which I have some basis for, but this is going to be a difficult letter to write. To the members, if anybody wants to provide me input on which direction using the conclusions should go, or provide me some write-up for the discussion, that would be fine, too. Please do so soon, because we need -- I mean, we have only really next week to work on this.

I am going to propose to write the conclusions maybe this week. Let me see. But I will try to get the conclusions and socialize them with the committee to see -- to get feedback. Then we'll get the letter done and keep going from there.

Any more comments or questions? Because we have plenty of time.

Okay. I hear nothing. Can somebody make some noise and affirm that I am still connected?

MR. SCHULTZ: Yeah. We hear you.

CHAIR MARCH-LEUBA: Okay.

PARTICIPANT: We are still there, Jose.

CHAIR MARCH-LEUBA: All right.

MR. SCHULTZ: The Reg Guide has been published.

CHAIR MARCH-LEUBA: Yeah.

MR. SCHULTZ: We're not -- the committee is not commenting on a draft guide that is going to be modified. It would be commenting on proposed changes in the future.

CHAIR MARCH-LEUBA: That is correct. So, basically, we are commenting on Revision 6. If we have a serious issue, we are commenting on Rev 6.

MR. SCHULTZ: Yes.

CHAIR MARCH-LEUBA: Now my -- my inclination now -- we are still on the transcript. My inclination now will be for reaffirming that we -- we still support previous ACRS recommendations and conclusions with the proviso that I believe the staff has done a fantastic job recommending the methodology.

So at least if somebody uses CAP, we know how to calculate it and what uncertainties are used. But we still believe it's not -- it reduces the -- an additional defense-in-depth layer, because the primary basis for -- for the way we work with reactors is that the layers, the protected boundaries are independent from each other.

And now by allowing CAP, you are defending the vessel with the containment. And they are not independent anymore, but we will work on the language

and see if we can make it happen.

MR. SCHULTZ: Okay. Great idea, Jose.

CHAIR MARCH-LEUBA: Any comments?

MEMBER HALNON: Yeah. This is Greg. That to me was the key issue coming out of this. It's not so much that the physics don't -- don't allow for pumps to survive as long as the pressure is there.

So, yeah, I need to think about that portion a little bit more and understand how the interplay between that and the other areas of defense-in-depth might be overlapping. Because you're basically right, we're reducing the independence of the barriers, which is a key portion of the defense-in-depth concept in my mind.

So, you know, I appreciate you voicing that because that's what I was struggling with throughout the presentation was the physics are fine to me.

CHAIR MARCH-LEUBA: Yes. The calculations are good.

MEMBER HALNON: Yeah. It's the concept and the policy and then the overall effect on the defense-in-depth barriers.

CHAIR MARCH-LEUBA: Yeah. And likely on the letter we need to take a position about advanced

reactors. I like the position of the staff that says that, well, if it applies to you, you use it. If you're like NuScale and you don't have CCS pumps, well, it doesn't apply to you.

And, Joy, you have some comments?

MEMBER REMPE: Well, it's just a thought that was kind of in my mind, since we're -- we have time to opine a bit.

The more -- the plants that are having difficulty in dealing with GSI-191 often use a risk-based argument to get over that hump. And the request that they evaluate this in a risk assessment is kind of interesting. You know, what we had suggested that was denied, and then yet that's what plants rely on when they want to try and keep operating, is my connection enough you can understand me?

CHAIR MARCH-LEUBA: Yeah. You sometimes break up a little bit. But you're doing good now.

MEMBER REMPE: Oh, okay. Well, the -- anyway, just a thought that has been running through the back of my mind that might be worth thinking about for the letter, but it's up to you. I don't feel that strongly about it, but it's just an interesting angle.

CHAIR MARCH-LEUBA: Yeah. God knows -- and you all know, too -- that I'm not a big proponent

of risk-informed anything. But for something like this, I would like to be informed about the risk that we are taking. I mean, it -- just saying no, we don't want to do it because we're doing it deterministically, it sounds hollow to me.

MEMBER PETTI: So I've been sitting listening, and of course, you know, I wasn't involved with any of the previous ACRS discussion. But it seems like, if you just think about how different a place we are in today than back when those letters were written, in terms of risk-informed regulation being more ingrained in the agency as part of its DNA, the letter, you know, can serve a really good purpose to reflect how different things are today than they were back then, even the fact that there is different Commissioners, right?

So some of that is important, and I -- I do want to explore this defense-in-depth thing a little bit more, because I -- what I really don't want to see is a -- there's sort of a practicality to using CAP. That's what the physics says, you know, would actually happen.

And if you have to weaken defense-in-depth a little in this small particular area, I just worry about sort of rigid -- I call it safety theology if

you will in light of, you know, some tactical considerations and how you balance that. To me, that's important and something we can I think talk about, you know, in full committee.

MEMBER BROWN: This is Charlie.

CHAIR MARCH-LEUBA: Yes. Yes.

MEMBER BROWN: I think I was here back when we started all this stuff back in 2008, '09, and all those -- the initial stuff. So was Dennis. And we went -- all the math that we went through today, the physics of the whole thing, was developed and presented in spades. And my memory was that we were very, very concerned as -- you know, I'm not much of a risk-informed person either, so it's deterministic.

But our emphasis was really on what was perceived as a -- in my mind, the gradual reduction in defense-in-depth type -- the defense-in-depth type concepts. And that's why the letter fundamentally -- that I think the last letter fundamentally said that. It was a defense-in-depth type issue.

And we've -- I understand Dave's comment relative to how things are more -- you know, the DNA is changing in terms of the risk-informed mode. But I think that needs to be tempered with the realistic thought process of not degrading the committee's

emphasis on defense-in-depth either.

So I agree with Jose's fundamental thrust. We may want to tailor it somehow, but that's -- Dennis can chime -- he was there also, and I -- I'm not sure -- Joy, I'm not sure when you -- you were there in 2011, weren't you?

MEMBER REMPE: Yeah. I started in 2010.

MEMBER BROWN: 2010. Okay. So you should have been party to some of this discussion as well, if I remember correctly.

MEMBER REMPE: You remember correctly.

MEMBER BROWN: Okay. So that's my memory. You know, admittedly, I'm pretty old now, so -- but the defense-in-depth issue weighed heavily on most of the members' minds. I think it was a fairly unanimous type approach. We did not -- it wasn't an eight to seven vote in terms of the tone of the letter. So that's also my memory.

But anyway, we didn't -- we don't have transcription during that voting period, so I don't know how we could recover that.

Dennis, do you have any other different memories than I do?

MR. BLEY: No. That's pretty close. The letter was -- letters were unanimous as far as I can

remember. I'm almost certain of that.

MEMBER BROWN: Yeah. That's my memory.

MR. BLEY: One of our members later became a Commissioner and voted against this, and some have held that against him ever since.

MEMBER BROWN: Was it George? You're talking about George?

MR. BLEY: Yeah. You know, the risk here is almost surely very low, but you ought to be more sure than you can from that statement by me. That's kind of it.

There had been a history of looking at CAP as not much for a very short time, and very short times had been just a few minutes, and then all of a sudden we had an application that really went much closer to losing that positive suction head.

And that time extended over a pretty long period of time, at least by comparison to anything they didn't look at before. And that was kind of a -- I think a shock for most people who first saw it.

But you had it right.

MEMBER BALLINGER: this is Ron. I mean, is it time for us to say in this letter, or some other place, that there is a -- in this case, there has been a bit of a conflict between risk-informing and

deterministic and having a little bit of a gray area there.

But that we ought to be sure that in the future -- or we should say something that this is -- this issue -- not CAP, but this issue of risk-based or risk-informed decision-making has the likelihood of running up against defense-in-depth again. And we ought to be sure that we say something like that, so that we're on the record, because it might be important in some future negotiation or discussion that we should have said this.

MR. BLEY: I think one thing you -- you folks who are still on the committee should consider is we had a series of essentially debates with the staff on this, and then we escalated it by sending a letter to the Commission saying, you know, we can't come to agreement with the staff.

And the Commission said, in terms of one of the Commissioners at the time, reasonable assurance is what we say it is, they said no, we're going with the staff. So whatever you write ought to be -- keep that in mind.

MEMBER BALLINGER: Yeah. I mean, we should think about reminding people of this.

MR. SCHULTZ: This is Steve. The other

piece that -- when the staff -- the committee presented its positions to the Commission, and the staff did as well, in the staff's presentation to the Commission -- and I think in the Commission's deliberations -- I haven't read the statements by the Commissioners.

But there were two things. One was the staff promoting an approach -- the analytical approach, which has been discussed today and now documented in the Reg Guide.

The second piece of that was looking at what the ACRS Committee was proposing, which was a strongly-based probabilistic risk assessment, fully-based probabilistic risk assessment, including external events, and so forth, that that was the approach that was being proffered.

And the staff and the Commission both evaluated what impact that would have on those licensees that were -- would need to reevaluate their use of containment accident pressure. And that was part of their -- I mean, that was part of their considerations. I don't know how much it affected their determination, but it was -- it was fully presented and evaluated by the staff in terms of what it would take for the staff to put together such an

approach and what it would mean with regard to licensees' not only reaction to it but the imposition that that could impose on the licensees and whether that was something that the Commission could do or would do.

So it's worthwhile -- it's worthwhile going back and reading -- reading the Commission's statements and the staff's presentation to the Commission at that time.

MR. BLEY: Yeah. I'd back Steve up on that. But read the Commissioners' vote sheets. They're still interesting, and kind of see where they stand.

Probably the strongest feeling on the committee at the time was unless there is some really outrageously expensive reason not to do it, you ought to fix this instead of coming in on -- relying on analysis.

MEMBER BROWN: Amen. I remember that we made those comments. It had to be really a very expensive approach to making a fix, and so it should be only under extenuating circumstances.

MR. BLEY: And I think the staff is -- I have to go back and read their words, but from their presentation it sounds like that's where they -- where

they stand. The first choice is to not have it as an issue.

MR. SCHULTZ: I saw that in the -- in the discussions, and it's reaffirmed in the guide.

CHAIR MARCH-LEUBA: Yeah. The guide says if -- if it's practicable to fix it, fix it. And then, if not, then start calculating.

Going back to what Steve said, I mean, because on -- from the logical point of view, having a Level 3 full-blown PRA, with all external events and everything, it's very expensive. And we keep getting comments back from industry, even on Part 53, saying gee, I have a little two-megawatt reactor that doesn't need it. Why do you want me to spend this many million dollars on a PRA that doesn't do anything?

So we need to be conscious that even though logically you should know the risk to the full extent of the calculation of ability, sometimes it's not worth the money.

MEMBER PETTI: Except that 52 requires it, and 50 will -- if the rule passes, would also require it for new plants. So --

CHAIR MARCH-LEUBA: Yeah.

MEMBER PETTI: -- there's an inconsistency here. So --

MR. BLEY: Well, you can found this stuff. You know, if you're simple, you just assume the worst case happens and see what -- what it looks like.

You know, the staff's position that the most likely way you lose pressure is to -- to have lost it initially by a bad valve lineup or something, so there's a leak. That's true.

But the idea of a really strong seismic event that could fail the containment and fail -- lead to a LOCA somehow is -- while it's pretty unlikely, but the combination is -- those kind of combinations come up in external events, fires, or seismic events -- in some old plants, wind events -- as the most likely way you get those combinations of things happening. So that's kind of where folks were coming from back then.

MR. SCHULTZ: Yes, Dennis. That's what -- what's why -- that's what I read into the letter that was prepared for the USPWR, APWR.

CHAIR MARCH-LEUBA: Yeah. And Steve sent me a reference to the APWR letters, and I would include them -- we'll include them back into the SharePoint and we'll send you a link, so you can read them. I haven't had time to read it myself. I just saw it was APWR.

Going back to a comment that Ron made half an hour ago, the way I put it is we, in ACRS, have a concern with this topic. We raised it, and we raised it, and we elevated it all the way to the Commissioners.

The Commissioners read it, understood it, and voted, and they were against us. So, in a sense, the issue has been resolved. I mean, we can continue to complain, but the issue has been resolved.

MEMBER BALLINGER: It's not a complaint. It's a reminder.

CHAIR MARCH-LEUBA: Yeah, yeah. It would be nice if we can gain some broader perspective that the problem applies -- the problem of not using risk information applies not only to RG 182 but new reactors, GSI-191, other things.

If we could frame it in -- in a lesson learned for other topics, it would sound more valuable, in my opinion.

MEMBER BALLINGER: Yeah. That's -- that I think was what -- the point I was trying to make.

CHAIR MARCH-LEUBA: Yes.

MEMBER REMPE: So that's --

MEMBER BALLINGER: I mean, P&P is kind of an academic exercise in some respects. But there may

be cases later on which aren't.

CHAIR MARCH-LEUBA: Joy?

MEMBER REMPE: Well, that's the reason I'm thinking this angle about what's going on, like with the Vogtle 1 and 2 request for GSI-191. They relied on risk assessment. South Texas Project did this, too, to get rid of GSI -- or get around GSI-191.

It's so related to this topic. I think it's a way to broaden it and point out that the more difficult ones have had to rely on risk assessment.

CHAIR MARCH-LEUBA: Yeah. I mean, it's not fair that the applicants get to rely on risk assessment only when they want to, only when it's good for them.

MEMBER REMPE: Yes. That's where I'm kind of thinking of going, but anyway, it's just an idea.

CHAIR MARCH-LEUBA: This letter is going to be very difficult, speaking of which, Joy, we have scheduled it for November. But the guide has been issued. If we are extremely busy and we cannot finish it in November, we can do it in December, we can do it in February.

MEMBER REMPE: This is all fine. Right now, we have three letters for November, and I've actually seen one draft and I think it's in really

good shape. But I think Dave's letter will be more difficult on Part 53, and this one may be.

But, you know, let's just see what we can get done. We have an extra half day in December.

CHAIR MARCH-LEUBA: I was just offering the fact that the guide was issued in August, and there is no hurry for our letter.

MEMBER REMPE: Sure. I meant to say, by the way, an extra half day in November. So, and we have time in November -- or December also, so let's see what we can do.

MEMBER HALNON: Jose, you stated that licensees shouldn't be able to just use risk information anytime they want to. That doesn't apply in this case. These plants that couldn't solve GSI-191 deterministically had to turn to the risk because of the -- it's not just because they wanted to. It's because it -- that was the best course of action.

I think that licensees should be able to use risk information if the deterministic and mechanistic areas of -- you know, just putting in bigger strainers is not possible. So I don't know. I just -- I'm not sure that's what you meant, but it sounded to me like you meant --

CHAIR MARCH-LEUBA: That's not what I meant. What I meant is I -- I don't know what the risk is when you allow CAP use. We suspect it's very small, but I don't know.

MEMBER HALNON: Okay. I got it. I thought you were making a broader statement, so I apologize.

CHAIR MARCH-LEUBA: Okay. I wanted to make another broad statement, Joy, and this is for your ears. This was -- half an hour was fantastic. We should have these discussions of the two committees more often, because more often than not, the committee chairman --

(Simultaneous speaking.)

CHAIR MARCH-LEUBA: -- then we complain about the commas and whiches (phonetic). We should do this more often. Just offering that for thought.

MEMBER REMPE: I agree. It's nice to have that flexibility.

MEMBER BALLINGER: But, you know, it really depends on the subject I think.

CHAIR MARCH-LEUBA: Yeah.

MR. BLEY: Well, it does, you know, but the committee is offering in a hurry to wrap up these --

MEMBER PETTI: I'm on a call that's going to end soon, yeah.

MEMBER REMPE: Dave, did you know you're -- you need to mute.

MEMBER PETTI: So should we just set a time for you to --

MEMBER REMPE: David, I'm going to mute you. Okay.

CHAIR MARCH-LEUBA: Okay. I'm going to mute everybody. Any more discussions?

MR. BLEY: Well, I was just going to make a suggestion to the committee. In recent few years, we've been really focused on not extending a meeting beyond the expected closing time and hurrying to close.

If you go back 20, 30 years, when I used to come to the committee, if there was an issue, they'd keep going until, you know, 10:00 at night to -- to make sure that they get everything worked out that they wanted to work out. And I don't see a problem with that, but that's up to you folks.

CHAIR MARCH-LEUBA: Yeah. I remember being trained on using the side door on Saturdays. We hadn't used it in the last four years.

Any more comments, guys?

MEMBER REMPE: Well, I have a comment for Ron that I'm hoping that November subcommittee SHINE will have that day when we're going through the memos and the letter and we'll have a similar type of discussion for him.

MEMBER BALLINGER: I have absolutely no doubt whatsoever.

(Laughter.)

MEMBER REMPE: Okay. Thank you, Ron. I just thought I'd kind of point that out.

CHAIR MARCH-LEUBA: Okay. So, with that, I'm going to let the Court Reporter go home. The official part of this meeting is over. You can -- you can stop it now.

(Whereupon, the proceedings in the above-entitled matter went off the record at 11:53 a.m.)

Reg Guide 1.82, Revision 5 GSI-191 Issues

ACRS T/H Subcommittee, October 20, 2022

Ahsan Salman

Steve Smith

RG 1.82 Changes in Rev. 5

- <u>GSI-191 (Main body of RG and Appendix A)</u>
  - New information on the effects of debris on long-term core cooling
  - Added specific information and references to evaluate debris in-vessel effects
- <u>Use of CAP (Appendix B)</u>
  - Added new Appendix B - guidance on the use of CAP in determination of NPSH margins
  - Applies to existing and new BWRs and PWRs licensed under 10 CFR Parts 50 and 52
  - Some plants are licensed to use CAP for determining available NPSH for ECCS and CHR pumps
  - RG 1.1 states only containment pressure prior to LOCA should be used in NPSH calcs
  - RG 1.1 withdrawn (4/2015); new CAP guidance to be included in RG 1.82, Rev 5.

Background

- GSI-191 Summary
- Regulatory Guide (RG) 1.82 Revisions Related to GSI-191
  - In-Vessel Guidance Updates (2019)
  - Penetration Testing Guidance
  - Improved Clarity and Detail
  - Updated Knowledge Base Report (2014)
  - BWR Evaluation of Lessons Learned (2018)
  - Updated Jet Testing (2012)
  - Test Debris Preparation Guidance (2012)

GSI-191 Summary

- USI A-43 sump strainer blockage unresolved issue identified in 1979
  - Closed in 1985
- Several generic communications after 1985 regarding debris and adequate NPSH margins
  - Some were BWR specific
- Through 1990s many cases of debris problems
  - Affecting pump operation
  - In containment and pumps (and suction lines)
- Several cases of damaged strainers
  - Debris could go downstream
- BWRs evaluated and closed issue in 2000

GSI-191 Summary

- Opened GSI-191 in 1996 for PWRs
- NRC completed review in 2002 finding sump clogging to be a credible concern
- Issued BL 03-01 and GL 04-02 requesting
  - Licensees to take mitigative actions
  - Provide assurance that long-term core cooling (LTCC) would be successful considering the effects of debris
- GSI remained open because some technical issues were not fully understood

GSI-191 Summary

- Licensees evaluated debris effects and replaced strainers with models with much greater area and better filtering designs
- Chemical and In-vessel effects were not well understood
- Methodology for chemical effects accepted in 2007
- Final methodology for in-vessel effects developed in 2019
- Upon establishing accepted method for in-vessel effects, GSI-191 was closed in 2019 (ML19203A303)
- Licensees must still respond to GL 04-02

GSI-191 Summary

- GL 04-02 Plant Status
  - 9 low fiber plants closed using original in-vessel guidance
  - 10 plants closed out deterministically after 2019 in-vessel guidance issued
  - 7 plants have deterministic submittals under review
  - 2 plants – NRC awaiting final deterministic submittals
  - Risk-informed resolution
    - 2 plants closed
    - 2 plants under review (1 of these in concurrence)
    - NRC Awaiting LARs from 2 plants

Reg Guide 1.82 Changes for GSI-191

- Reference to Draft RG 1.229 for RI evaluation of debris effects (ML15335A179)
- BWROG evaluation of lessons learned since the BWROG closure
  - BWROG stating issues reviewed, no further concerns - ML17326A393
  - NRC Staff Technical Evaluation - ML18058A602
  - NRC letter accepting BWROG position - ML18078A061

Reg Guide 1.82 Changes for GSI-191

- NRC In-vessel Downstream Effect (IVDE) Safety Significance TER - ML19073A044
  - Evaluates risk of physical aspects of in-vessel debris effects on long-term cooling
  - Discussed with ACRS TH Subcommittee in April and September 2019
- NRC Staff Review Guidance for IVDEs - ML19228A011
  - Provides guidance commensurate with plant conditions and reactor/fuel design ability to accommodate debris in the vessel
  - Relies on findings from WCAP-17788-P and TER (above)
  - Discussed with ACRS TH Subcommittee in May 2021 (Vogtle LAR)

Reg Guide 1.82 Changes for GSI-191

- WCAP-17788-P, Revision 1 – Package - ML20010F181, Volume 1 - ML20010C854
  - Significant headloss testing, chemical testing, and TH analysis
  - No SE written by NRC, but found to provide significant increase in knowledge of behavior of the system with debris effects
  - NRC validated TH work using TRACE
- Added a few other references noted on slide 3

RG 1.82 Status With Respect to GSI-191

- Revision 5 to RG 1.82 was performed after the closure of GSI-191
- RG 1.82, Rev 5 is a complete guidance document for the effects of debris on long-term core cooling
- Additional guidance may be issued as the result of the 10CFR50.46c rulemaking currently with the Commission
  - RG 1.229 on risk-informed evaluation of debris on LTCC
  - Unlikely for the RG to be used after the rule is finalized
  - RG contingent upon the rulemaking and may be left as-is, deleted or revised

Reg Guide 1.82, Rev. 5 Public Comments

- NRC received 4 sets of public comments from 3 entities
- Comments received in areas of:
  - Applicability and Scope – relevance to alternate designs
    - NRC position is that RG is guidance, only applied where appropriate
    - Rev. 5 not intended to cover new reactors except when guidance is applicable
  - Definitions, Clarifications, and References
    - NRC made changes where appropriate
  - Add Risk-Informed Guidance
    - No changes made, awaiting 50.46c rulemaking

Reg Guide 1.82, Rev. 5 Public Comments

- Comments in the area of:
  - Specificity of Methodology and Failure Criteria
    - NRC concluded methodology is described as desired
      - Requested additions assumed that information included as an example in a SECY paper referenced in the RG was intended to have global applicability to all plants
      - Made reference in the SECY public in ADAMS
    - Comments suggested including methods for evaluations outside the scope of the RG
      - No changes made
  - Editorial comments in Appendix B
    - Incorporated

FLEX Equipment – Defense-in-Depth

- FLEX strategies are designed for beyond-design-basis external events initiated by natural phenomena
  - Not intended or reviewed for response to postulated accidents
  - However, some equipment may be available for accident response DID
  - There is adequate FLEX electrical power (or diesel) for all equipment
- Flex equipment and strategies are different between BWRs and PWRs
  - BWR FLEX includes equipment for direct connection to the RCS and the ability to vent containment if needed
    - RCS Blowdown is typically via SRVs to the suppression pool
    - BWR strategy is typically to vent containment for pressure reduction, if needed
  - PWR FLEX RCS injection only has low volume pumps with connections to the RCS
    - For Shutdown or low leakage only, includes borated water supply
    - Decay heat is removed via the steam generators with higher volume pumps
    - Connecting steam generator FLEX pumps to the RCS may be possible for some plants but has not been pre-planned or verified to be feasible in general
    - No pre-determined strategy for containment pressure reduction

FLEX Equipment – Defense-in-Depth

- Strainer blockage
- For most strainer blockage events RCS pressure would be low
  - BWRs have deployable FLEX capability to supply the RCS
  - Unclear if PWRs would be able to reconfigure the SG FLEX pumps and provide piping connections to inject large volumes of water within required timeframe
  - PWRs have low volume injection (typically 10s of gpm) for shutdown conditions or for pump seal leakage that are pre-configured for connection
- BWRs FLEX strategies may provide DID for long-term cooling
  - May need to consider containment venting and water level control strategies, etc.
- PWRs FLEX strategies may generally be less effective as DID for long-term cooling
  - Effectiveness depends on plant-specific equipment capacities, layouts, connections, etc.
  - No boration available at higher flow rates
  - Lower flows could be adequate if it takes a long time for strainer blockage to occur
    - Depends on plant-specific pump capacity

FLEX Equipment – Defense-in-Depth

- Loss of CAP that is credited to assure NPSH margin
- This scenario is likely very similar to the strainer blockage case
- For the FLEX scenarios, PWRs do not assume high containment pressure
  - Small energy release to containment from RCP seals
  - Similar constraints to those for the strainer blockage case
- BWRs may be able to use FLEX to provide RCS injection in the case of loss of NPSH
- PWRs would have challenges like those for a blocked strainer

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

RG 1.82, REVISION 5, APPENDIX B

GUIDANCE FOR THE USE OF CONTAINMENT ACCIDENT PRESSURE IN DETERMINING THE NET POSITIVE SUCTION HEAD MARGIN FOR EMERGENCY CORE COOLING SYSTEM PUMPS AND CONTAINMENT HEAT REMOVAL PUMPS IN BOILING WATER REACTORS AND PRESSURIZED WATER REACTORS

CONTENTS

1. Background

- CAP Issue
  - Use of CAP in determining NPSHa for ECCS and CHR pumps critiqued by the ACRS
  - Published regulatory guidance was not clear and consistent
- EPU LAR reviews discontinued because of CAP issue
  - Browns Ferry Units 2 & 3 EPU (15%), June 2004, 5% was previously approved
  - Browns Ferry Unit 1 EPU (20%); only 5% was approved, June 2004,
  - Monticello EPU, October 2009
- BWROG submitted topical report NEDC-33347P / NEDO-33347 (2/2008) providing a standard approach for requesting CAP in NPSH analysis.
- Staff transmitted white paper (11/2008) to ACRS summarizing regulatory and technical bases on CAP.
- ACRS recommendations to EDO (letters 3/18/09 & 5/19/10)- key items (item with * are included in guidance)
  - CAP credit should be limited in amount and duration
  - *Licensees to use RG 1.82, Rev 3 (current version at that time) to demonstrate +ve NPSH margin
  - *Revise RG 1.82 to incorporate guidance.
  - *Operator actions to control CAP should be reliable, risk should be acceptably small.

Background (Continued)

- SRP 6.2.2 should be revised to state if CAP is granted based on risk info.
- *Before CAP credit, licensees to justify impractical to modify plant
- For licensing, CAP deterministic calc should be complemented by PRA
- *Support staff reassessment of problems with NPSHa ≤ NPSHr
- *Agree with BWROG statistical calcs to understand NPSH margin
- *Margin (NPSHa – NPSHr) to consider uncertainty in NPSHr
- *Hardware modification or risk studies not needed for small CAP credit (in deterministic analysis)
  - If no CAP credit is needed for special events
  - 95/95 lower tolerance bound for LOCA using acceptable method shows no CAP credit is needed.
- Staff PRA studies presented are helpful, to assess risk need plant-specific studies.

- EDO Letters to ACRS (6/4/2009 & 6/10/2010)
  - Staff is reviewing ACRS recommendations
  - Submittal of BWROG report a significant milestone
  - Address policy issues before including risk in non-risk informed LARs.

Background (Continued)

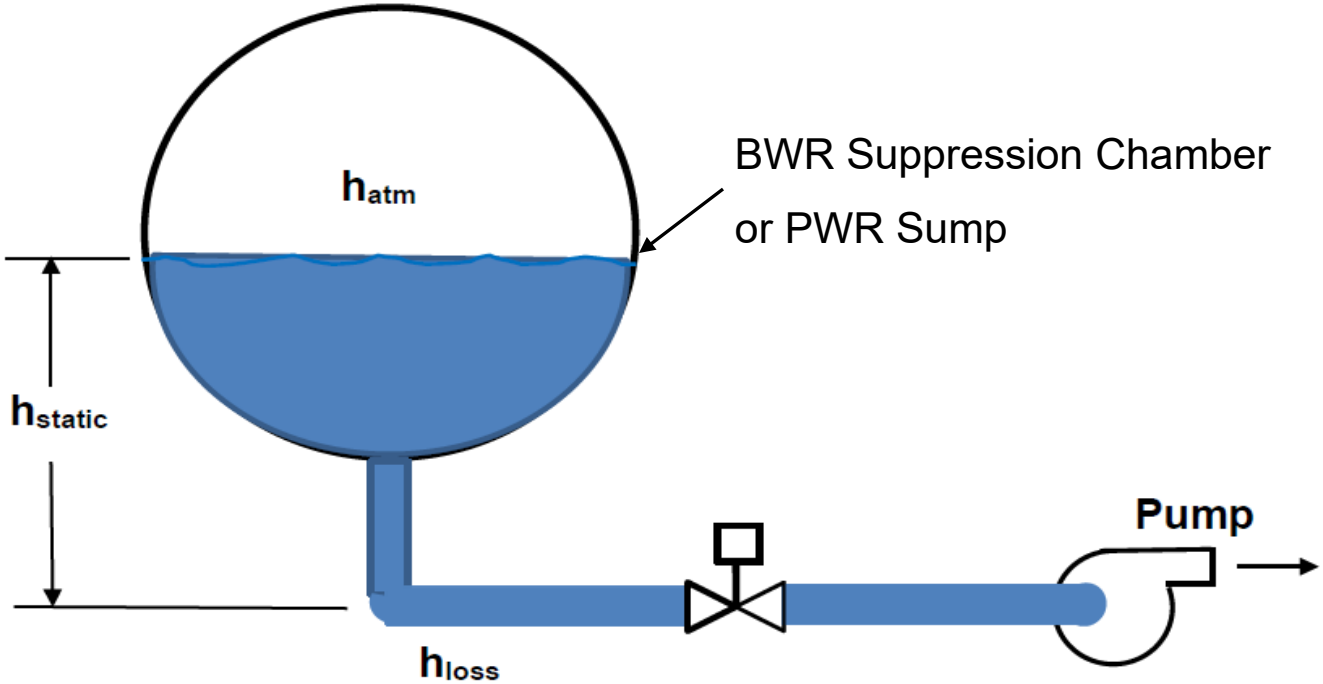
- ACRS Letter to Commission Chairman (2/17/2011)
  - Disagreement between ACRS and staff
  - ACRS Position - CAP credit is a serious compromise of independence of prevention and mitigation which is a basic element of defense-in-depth philosophy; CAP is granted only if design cannot be practicably altered.
  - Staff Position - Analysis showing CAP provides adequate NPSH is as acceptable as design change that eliminates the need for CAP credit. No regulatory basis to request licensees to provide plant-specific risk information to assess the challenge to defense-in-depth.
- Pump Consultant – Allan R. Budris Reports (October & November 2009)
  - Task # 1- Review Sulzer Browns Ferry RHR and LPCS pump report (ML062920156), and evaluate overall methods for NPSHr
  - Task # 2 – Determine accuracy and uncertainty in $NPSHr_{3\%}$
  - Task # 3 – Evaluate technical justification for allowing pump operation in cavitation
  - Task # 4 – Evaluate NRC criteria of basing CAP at zero NPSH margin (Nov 2009)

Background (Continued)

- SRM (6/25/2010) & SECY-11-0014
  - Staff paper to discuss where staff aligns and where it disagrees with ACRS including risk, defense-in-depth and hardware changes to eliminate CAP.
  - Staff responds to SRM (1/31/2011); SECY-11-0014; options for Commission vote:
    - Option 1, Staff approach, deterministic, uncertainty and margins
    - Option 2, ACRS approach includes staff approach + plant specific PRA
  - Commission votes (3/2011), Option 1 – four votes; Option 2- one vote
  - Commission approved (3/15/2011) SECY-11-0014 with Option 1
- Commission directed staff to credit CAP using guidance in SECY-11-0014, Enclosure 1.
- Draft guidance based on SECY-11-0014 sent to PWROG and BWROG (2/25/2011)
- RG 1.82, Revision 5, Appendix B is based on SECY-11-0014, Enclosure 1.

2. Key Terms (RG Sections B-1 and B-6)

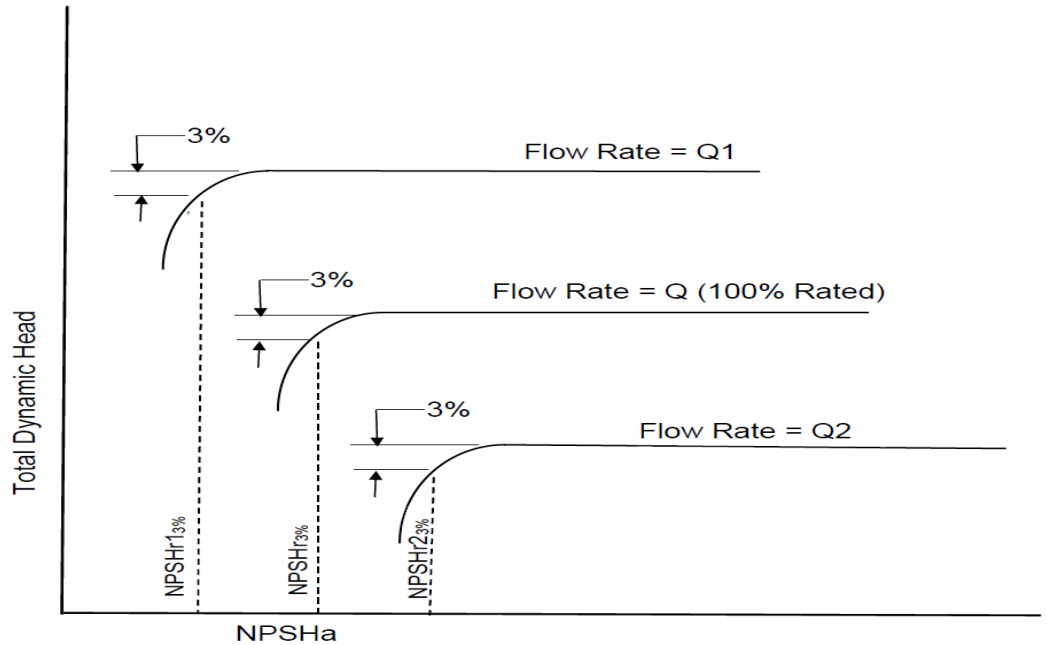
NPSH Available (NPSHa) (RG Figure B-6)



- NPSHa = $h_{atm} + h_{static} - h_{loss} - h_{vp}$
- h_{vp} = vapor presure at suppression pool or sump water temperature
- CAP = pressure greater than containment pressure prior to accident or an event.

Key Terms (Continued)

NPSH Required (NPSHr)



- $NPSHr_{3\%}$ according to ANSI/HI 14.6-2016 is the NPSH that results in cavitation sufficient to reduce the pump total dynamic head (TDH) by 3%.
- $NPSHr_{3\%}$ (from factory test) depends on pump design, flow and water temperature.
- In-plant installed pump NPSHr may differ from $NPSHr_{3\%}$ due to difference in test conditions and plant conditions.
- NPSH Margin = (NPSHa - NPSHr)

Key Terms (Continued)

- NPSH Margin Ratio = (NPSHa / NPSHr)
- Cavitation
  - Occurrence of vapor-filled cavities in a liquid (Grist, *Cavitation and the Centrifugal Pump: A Guide for Pump Users* (RG Ref. B-1)).
  - In a pumped liquid, cavitation is the formation of vapor-filled cavities in the liquid flow due to a decrease in the local static pressure below its vapor pressure.

3. Role oF ECCS and CHR Pumps (RG Section B-2)

- BWRs (RHR and LPCS Pumps)
  - Cooling of RCS during shutdown (RHR)
  - Suppression pool cooling normal operation when heat is added (RHR)
  - LPCI and core spray in reactor following LOCA (RHR and LPCS)
  - Suppression pool cooling during LOCA or special events (RHR)
  - Containment spray for containment cooling and fission product removal (RHR)
- PWRs (RHR and CS Pumps)
  - Safety injection following LOCA during sump recirculation phase (RHR)
  - Containment spray following LOCA to cool containment & remove fission products (CS)
  - RCS cooling during shutdown (RHR)

4. <u>Regulatory Requirements and Guidance (RG Section B-3)</u>

- 10 CFR Part 50. Appendix A
  - GDC 35, "*Emergency core cooling*,"
  - GDC 38, "*Containment heat removal*,"
- Guidance in this RG Section C.1.3.1 includes:
  - RG 1.1 position
  - Conservative calculation of transient NPSHa and available CAP.
  - Prototypical test for crediting pump operation in cavitation
  - Calculation of pumped water temperature
  - **He**ad loss in the suction strainer and piping
- Uncertainty Analysis & NPSH Margin
  - For NPSH margin, current approach assigns bounding inputs for LOCA containment temperature, NPSH analysis
  - For DBA, in BWROG topical report NEDC-33347P-A/NEDO-33347-A, CAP is determined by Monte Carlo calculation.
  - For special events, realistic inputs may be used, and licensee to quantify uncertainty.

5. Use of CAP in Determining NPSH Margin (RG Section B-4)

- NPSHr should correspond to acceptable level of cavitation that allows the pump to perform its safety function for accident duration and recovery time.
- $NPSHr_{3\%}$ is typically obtained by factory testing of the actual pump or a similar one in accordance with ANSI/HI 14.6-2016.
- NPSH margin = (NPSHa – $NPSHr_{eff}$), where $NPSHr_{eff}$ = $NPSHr_{3\%}$ + uncertainties
- NPSH margin should be greater than or equal to zero.
- Difference in the factory test $NPSHr_{3\%}$ and field $NPSHr_{eff}$ is due to the following:

– Pump speed (because of motor slip)
  - ➢ NPSHr varies as square of the pump speed, which changes with motor slip.
  - ➢ Pump may operate at slightly higher speeds in field compared to a factory test speed

– Water temperature
  - ➢ The NPSHr decreases as water temperature increases.
  - ➢ Factory tests mostly at lower temps than field resulting in increased NPSH margin.
  - ➢ Effect of water temperature should not be considered in the field NPSHr

Use of CAP in Determining NPSH Margin (Continued)

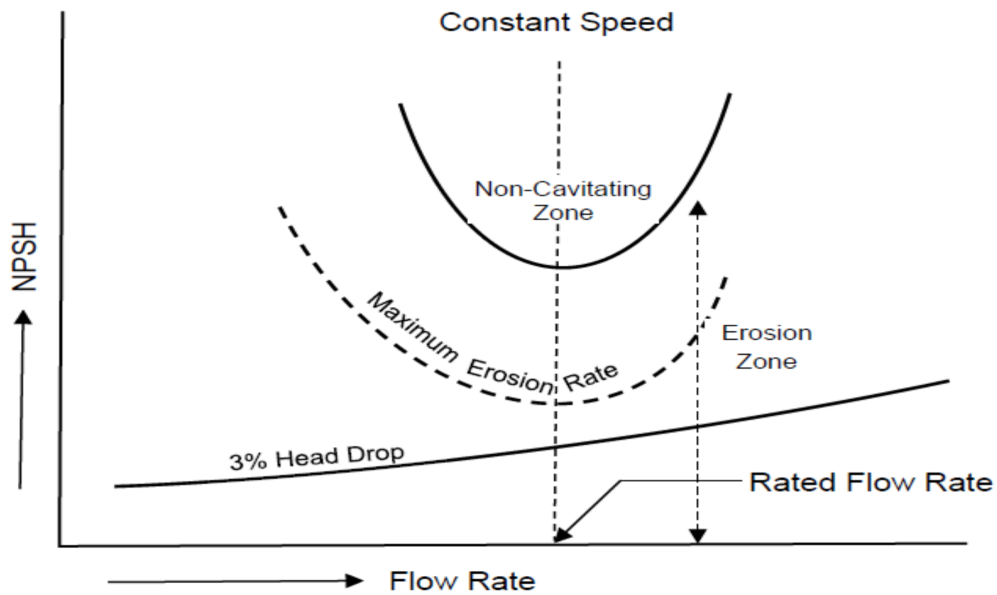
- Suction piping configuration
  - For acceptable pump operation, uniform inlet flow, free of swirl, and vortices.
  - Short and straight suction piping for better performance, may not be possible in field
  - Pressure loss in suction piping should be minimized to obtain the maximum NPSHa.
- Air content of water (may be lower in the vendor's test than in the field)
  - Dampens the effect of cavitation
  - It increases the NPSHr,
  - Release of the noncondensable gases affects the NPSH margin
  - May interfere with the water cooling of pump seals.

- Licensee to determine and propose uncertainty in $NPSHr_{3\%}$
- For DBA NPSH analysis, $NPSHr_{eff}$ should be used to determine the NPSH margin.
- For BWRs SBO, ATWS, and Appendix R fire events $NPSHr_{3\%}$ may be used for NPSH margin, and realistic assumptions may be used for NPSHa analysis
- EPU LARs in DBA analysis used bounding value of 21% uncertainty (Budris report)

Use of CAP in Determining NPSH Margin (Continued)

- Negative NPSH margin is acceptable if tests done to demonstrate that the pump will perform its safety function(s), and following should apply:
  - Operation for a limited duration (less than 100 hours)
  - Actual pump or similar (model, size, materials, and seal/flush system) is tested.
  - Tested at same speed as at the plant site.
  - Tested at the actual predicted NPSHa,
  - Test duration is for the time during which NPSH margin is negative
  - Flow and discharge head should be greater than required for safety analysis.

6. Cavitation Erosion (RG Section B-5 and Figure B-4)



- Insufficient NPSH margin results in pitting of impeller blade and other pump parts due to condensation caused by vapor bubble implosion near a solid surface.
- Visual studies, acoustical measurement, field experience shows maximum erosion rate occurs at NPSHa value between $NPSHr_{3\%}$ and cavitation inception (margin ratio 4)
- Pump tests indicate that the zone of maximum erosion rate lies between NPSH margin ratios of 1.2 and 1.6 for pumps operating outside of the zone of suction recirculation

7. Effect of Non-Condensable Gas on Pump Mechanical Performance (RG Section B-7)

- Large quantity of entrained air from suction source, vortices, or released from solution can affect pump mechanical performance.
- Configuration of the PWR sump or BWR suppression pool should consider eliminating entrainment of air (by sprays) and vortices.
- NUREG-0897 - vortices decay to negligible levels within 14 pipe diameters.
- For NPSHa close to $NPSHr_{3\%}$, vapor or entrained air could damage the shaft seal faces, therefore dual seal with external cold water flush system should be provided.
- If CAP used is determined assuming NPSHa = $NPSHr_{eff}$, then safety analysis flow should be equal to or less then flow resulting from a 3-percent decrease in TDH.
- Time of operation in the region of maximum erosion should be limited.

8. Loss of Containment Isolation and Containment Leakage (RG Section B-7)

If CAP is used, the licensees should-

- Demonstrate loss of containment integrity and loss of containment isolation cannot occur.
- Reduce the likelihood of a preexisting leak by determining minimum leakage rate sufficient to lose the needed CAP.
- Propose a method to determine whether the actual leakage rate exceeds the calculated.
- For inerted containments, periodic measurement of nitrogen makeup or oxygen content.
- Propose a time limit plant can operate without losing the needed CAP.

9. Containment Cooling if CAP Is Used (RG Section B-7)

- Licensees should demonstrate sprays and coolers will not reduce needed CAP.
- Operator action to control the CAP by sprays or coolers is acceptable if justified.
- Adequate guidance should be included in the operating procedures.

10. Illustration of h_{atm} and CAP Available (RG Section B-6, Figure B-8)

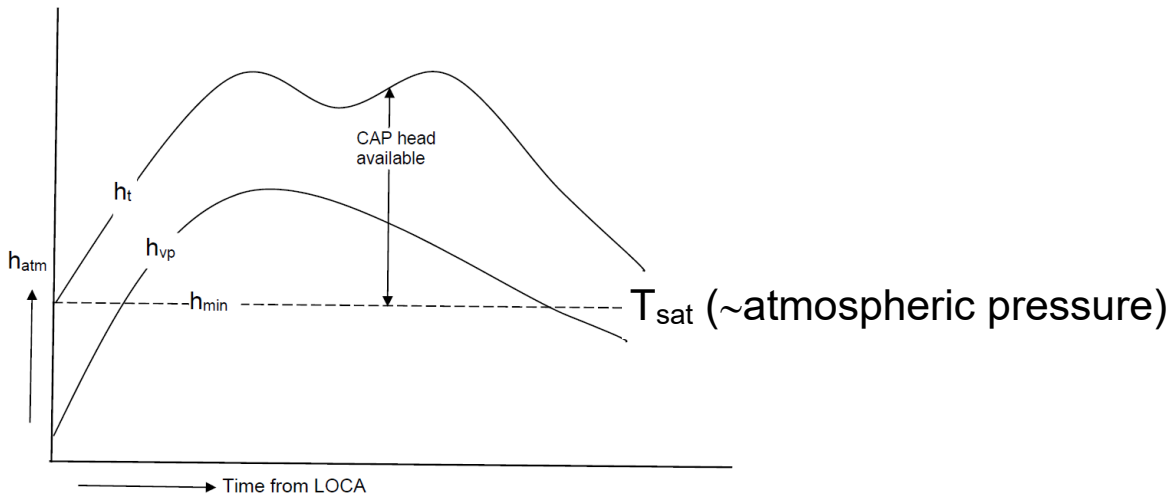


Figure B-8: Illustration of "h_{atm}" and "CAP head available" for $T_{pmax} > T_{sat}$

Perform conservative containment analysis to determine T_{pmax} and transient h_t, T_p and h_{vp} - **[A]**

- If $T_{pmax} > T_{sat}$ and needed CAP ≤ (h_{vp} - h_{min})
  - Determine the needed CAP for NPSHa = $NPSHr_{eff}$
  - Perform NPSH analysis - **[B]**
  - [A] and [B] is the design basis
- If $T_{pmax} > T_{sat}$ and needed CAP is between h_t and h_{vp}, i.e., (h_t ≥ CAP > h_{vp})
  - Determine the needed CAP for NPSHa = $NPSHr_{eff}$
  - Perform statistical (Monte Carlo 95/95) containment and NPSH analysis to determine margin
  - Perform NPSH analysis - **[C]**
  - [A] and [C] is the design basis

11. Quantifying NPSH Margin (RG Section B-8)

- DBA LOCA
  - Conservative (bounding) containment and NPSH analysis using bounding inputs.
  - Perform realistic analysis to determine margin
  - NRC calculation showed conservative NPSH values are close to 95/95 lower tolerance limit of Monte Carlo calculation of same problem.
  - Monte Carlo lower tolerance limit of NPSHa is acceptable for conservative case
  - NPSHr should include its uncertainty
- BWR special events
  - Realistic NPSH analysis is acceptable, i.e., nominal inputs based instead of TS LCOs or bounding inputs
  - Use conservative inputs if realistic values are not available
  - NPSHr may be used without uncertainty

12. Guidance Summary (RG Section B-9)

- For DBA, NPSH analysis should use NPSHreff = (1 + uncertainty) $NPSHr_{3\%}$
- For BWR special events, $NPSHr_{3\%}$ may be used to calculate margin
- Maximum flow rate for NPSHa analysis ≥ flow rate used in safety analysis
- Loss of containment integrity (venting) should not occur during CAP use.
- NRC-approved operator action to control CAP is acceptable.
- Negative NPSH margin is acceptable if tests done to demonstrate that the pump will perform its safety function(s) with certain conditions.
- To reduce the likelihood of a preexisting containment leak, following should apply:
  - Determine the minimum leakage rate to lose CAP needed for +ve NPSH margin.
  - Propose a method to determine leakage rate.
  - Propose a time limit for operation while the actual leakage exceeds rate determined
- Zone of maximum erosion rate should be between NPSH margin ratios of 1.2 and 1.6.
- BWRs, CAP should follow topical report NEDC-33347P-A/NEDO-33347-A
- PWRs, CAP options are: use the vapor pressure corresponding to the sump water temperature or use a procedure similar to the BWROG Monte Carlo method.
- Mission time for pump using CAP to include recovery time from the accident.

13. EPU LARs Approved (Using CAP Guidance in SECY-11-0014)

- Monticello LAR review reactivated
- Browns Ferry Units 1, 2, & 3 LAR resubmitted
- Other LARs following CAP Guidance in SECY-11-0014 include
  - Peach Bottom 2 & 3 (modified hardware)
  - Grand Gulf
  - Turkey Point 3 & 4
  - St Lucie 1 & 2
  - Point Beach Units 1 & 2

14. Acronyms and Symbols

Acronym	Description	Symbol	Description
ATWS	Anticipated Transient Without Scram	h_{atm}	Containment pressure head
BWR	Boiling Water Reactor	h_{min}	Minimum pressure head at normal plant operation
BWROG	BWR Owners Group	h_t	CAP head
CAP	Containment Accident Pressure	h_{vp}	Transient vapor pressure at supp pool (BWRs) or sump water (PWRs) temperature during an accident
CS	Containment Spray		
DBA	Design Basis Accident	h_{loss}	Strainer and pump inlet piping head loss
CHR	Containment Heat Removal	h_{static}	Static head at pump inlet
ECCS	Emergency Core Cooling System	T_{pmax}	Maximum suppression pool or sump water temperature
EPU	Extended Power Uprate	T_{sat}	Saturation temperature at h_{min}
LAR	License Amendment Request		
LOCA	Loss-of-Coolant Accident		
LPCI	Low Pressure Coolant Injection		
LPCS	Low Pressure Core Spray		
NPSH	Net Positive Suction Head		
NPSHa	NPSH Available		
NPSHr	NPSH Required		
$NPSHr_{3\%}$	NPSHr corresponding to 3% pump TDH drop at a given flow		
$NPSHr_{eff}$	NPSHr Effective		
OG	Owners' Group		
PWR	Pressurized Water Reactor		
RCS	Reactor Coolant System		
RG	Regulatory Guide		
RHR	Residual Heat Removal		
SBO	Station Black Out		
TDH	Total Dynamic Head		