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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

THERMAL-HYDRAULIC PHENOMENA SUBCOMMITTEE

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WEDNESDAY,

AUGUST 20, 2003

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ROCKVILLE, MARYLAND

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The subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Graham B. Wallis, Chairman, presiding.

COMMITTEE MEMBERS:

GRAHAM B. WALLIS, Chairman

F. PETER FORD, Member

THOMAS S. KRESS, Member

VICTOR H. RANSOM, Member

STEPHEN L. ROSEN, Member

JOHN D. SIEBER, Member

ACRS STAFF PRESENT:

SANJOY BANERJEE, ACRS Consultant

RALPH CARUSO, ACRS Staff, Designated Government Official

SAM DURAISWAMY, Technical Assistant ACRS/ACNW

NRC STAFF PRESENT:

RALPH ARCHITZEL, NRR/DSSA/SDLB

DR. T.Y. CHANG, RES/DET/ERAB

ANTHONY H. HSIA, RES/DET/ERAB

JOHN LEHNING, NRR/DSASA/SPLB

ALSO PRESENT:

JOHN BUTLER, NEI

DR. BRUCE LETELLIER, Los Alamos National Laboratory

I-N-D-E-X

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

(8:33 a.m.)

CHAIRMAN WALLIS: The meeting will now come to order. This is a continuation of the meeting of the Thermal Hydraulics Phenomena Subcommittee of the Advisory Committee on Reactor Safeguards which began yesterday. So I don't think I need to read the entire introduction.

I am Graham Wallis, the Chairman of the subcommittee. Subcommittee members in attendance are Tom Kress, Victor Ransom, Jack Sieber, Peter Ford, and Steve Rosen.

Today we are going to consider Regulatory Guide 1.82, Revision 3, entitled "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident."

This looks like a topic which is significant, at least potentially significant, to safety and poses quite interesting challenges, both technically and from the regulatory point of view. So we're looking forward to your presentation.

I invite Tony Hsia to get us started.

MR. HSIA: Thank you, Chairman Wallis, and members of the committee. My name is Tony Hsia from the Engineering Research Applications Branch in the

Office of Research. With me today on my right is Dr. T.Y. Chang, also in the same branch with me. To his right is Dr. Bruce Letellier, a consultant from Los Alamos National Laboratory.

Also, I see in the audience we have our colleagues from NRR, and this is a pretty extensive effort. As you have seen reading the background information in the Reg. Guide, it can be traced back -- this issue on sump performance -- traced back to even the early '80s. And we spent a lot of time, very extensive effort, in the late '90s until now.

We have worked very closely with our colleagues at NRR. This is a coordinated effort. And just from the outset I would like to state this Reg. Guide 1.82, Revision 3, is applicable to all plant designs, current and future. With the focus -- because it's related to GSI-191, our focus will be on PWR designs.

So if you can -- if you look at page number 2, we have an overview. This basically encapsulates what we're going to discuss today -- background. And we'll go over to the reasons for why we issued Rev. 3 and what Reg. Guides are intended to be used. And also, I'll summarize the activities related to Reg. Guide 1.82, Rev. 3 up to date.

Then, T.Y. will take over and discuss the key revisions in this current Reg. Guide and resolution of public comments. He will select the most significant and most numerous public comments and how we responded to those for your consideration.

After that, the bulk of the discussion will be the summary of the Reg. Guide as well as a discussion of the accident sequences. And we propose to do it in a tag-team approach. T.Y. will focus on the Reg. Guide itself and what the Reg. Guide says, and Dr. Letellier will get into the technical details. And then, T.Y. will wrap it up regarding the research future activities.

Next viewgraph, please.

Just a quick summary of where we have been. Back in 1974, Rev. 0 of Reg. Guide 1.82 was available, and in that Reg. Guide we discussed net positive suction head calculation based on a very simple assumption of 50 percent of the screen was blocked to figure out the NPSH performance.

And then, USI A-43 was started in January of '79. That focused on the containment emergency sump performance. And additional research was performed until 1985; we have issued a Rev. 1 of the Reg. Guide, which is a guidance based on the resolution of USI A-43, to instead of using a 50 percent blockage, we're going to say that's not sufficient. We're going to have 100 percent blockages, most conservative assumption.

Starting in the '80s, or early '90s I should say, several nuclear plants started from the Barseback plant in Sweden, and several domestic plants -- mostly BWRs -- ran into the sump -- or I should say strainer, suction strainer blockage events. And that really brought a lot of attention to the agency as well as the industry.

Some additional research was done, and in May of 1996 issued Rev. 2. In that, the effort was focused on the revised guidance for the BWRs. And also, NRC issued both in 96-03. That's on potential plugging of the suction strainer in BWRs, and requested licensees to implement measures to ensure that ECCS functions will perform as designed following a LOCA.

Then, in the late '90s -- well, in the meantime, additional research was performed, and we've switched attention more from BWRs to the PWRs, to see how the PWRs would perform. In late '90s, I believe it was '96/'97 timeframe, GSI-191 was issued. That focused on sump performance of PWRs.

And that's where we are today. Basically, at that stage, the Rev. 2 stage, we are asking the industry to assume 100 percent blockage unless they can justify through test or analysis that they can have a more realistic estimate.

CHAIRMAN WALLIS: Well, 100 percent blockage, does that mean that the pumps just cannot pump any water?

MR. HSIA: Assume that 100 percent blockage of the screens.

CHAIRMAN WALLIS: That means the pumps cannot pump any water?

MR. HSIA: No.

CHAIRMAN WALLIS: So we have to assume the pumps are inoperable?

MR. ARCHITZEL: That's one of the recommendations at Rev. 2. This is Ralph Architzel. It just means that you're not having 50 percent -- an arbitrary 50 percent assumption. It's a mechanistic assumption that you had blockage and it can be uniform over the surface. You still get water through. It's an analysis done to say that you --

CHAIRMAN WALLIS: And you have to show -- you assume 100 percent blockage. That means that there is something over the whole surface.

MR. ARCHITZEL: A hundred percent coverage of the surface.

CHAIRMAN WALLIS: In order to figure out whether the pumps will work or not, you have to know what that stuff is.

MR. ARCHITZEL: Exactly.

CHAIRMAN WALLIS: And so you haven't really, with this assumption, given enough information to solve the problem.

MR. HSIA: Correct. That's why we're continuing to do research, and that's the most conservative way to do it at that time.

CHAIRMAN WALLIS: Well, it isn't really conservative yet, because you haven't said what the blockage consists of. It could be 100 percent of insignificant stuff.

MR. HSIA: Could be.

CHAIRMAN WALLIS: So it's not really conservative yet.

MR. HSIA: Okay.

CHAIRMAN WALLIS: Until you say what that stuff is.

MR. HSIA: Correct.

CHAIRMAN WALLIS: You said it was blocked so much that the pumps couldn't work. That seems to me is a conservative assumption. Otherwise, it doesn't say anything. It just says there is something on the screen everywhere, and that doesn't really say anything until you say what you mean.

DR. LETELLIER: I think you'll see in the research efforts that the debris generation and transport tests have, in fact, characterized what types and amounts of material might arrive on --

CHAIRMAN WALLIS: Might, yes. Might. But I read in your report there are 13,000 cubic feet of fiber in some of these -- in the air handling equipment, for instance, in the containment. Now, if any one percent of that gets on a screen, it blocks it completely.

DR. LETELLIER: There's the potential for 100 percent coverage with an attendant head loss associated with that bed.

CHAIRMAN WALLIS: Yes, it's all potential. It's all "it might happen." It's not an assumption that lets you calculate anything yet.

MR. HSIA: Correct. That's why we at this point have stuck -- continued to gain knowledge. Right now, at this stage, our thought was the plant needed to do plant-specific analysis. Some plants may not have that kind of issue. It depends on how -- the probability of their break and where they assume the break.

So that brings us to where we are today is Rev. 3. And we're here today -- hopefully, we'll -- our plan is to have Rev. 3 -- with your approval, we'll issue the Rev. 3 shortly.

CHAIRMAN WALLIS: Oh. We can stop it?

MR. HSIA: Correct. Correct.

CHAIRMAN WALLIS: Thank you.

MR. HSIA: Hopefully, that's not the outcome we're here for. The reason --

CHAIRMAN WALLIS: It depends on how much blockage we want to insert in your process.

MR. HSIA: Correct. And we have to find ways to justify it.

CHAIRMAN WALLIS: Okay. Yes, please. Please do that.

MR. HSIA: Okay. The reason for issuing Rev. 3 is to contribute to the resolution of GSI-191, to enhance the blockage evaluation guidance for PWR, and to provide guidance to make sure we put out there methods acceptable to the staff, because, like I said earlier, Rev. 2 -- we felt that Rev. 2 of Reg. Guide 1.82 was not comprehensive enough to ensure adequate evaluation of PWRs susceptibility.

I just want to clarify that Reg. Guides are not a substitute for regulations, and compliance is not required. And we will talk a little bit about alternative methods that -- as a matter of fact, that's one of the --

CHAIRMAN WALLIS: That's rather funny. You know, they have this thing that compliance is not required. So that's why I couldn't understand about this whole exercise. Out goes this Reg. Guide, and it looks like a really serious matter. And it's quite likely, it seems, that some -- quite a few plants will not be able to meet all of these requirements in this Guide. So what then happens?

MR. HSIA: Okay. Yes. The Reg. Guide points out one or several acceptable methods in --

CHAIRMAN WALLIS: But it's also a subpart of the regulations. So what happens when they can't do it?

MR. HSIA: If they cannot do it, or they choose not to use the methods described in here, they can come up with their own methods. And that's the time that they have to send it in here. Either way, they have to send it here for --

MEMBER KRESS: It's in the regulations that they have to assure that you can do the longer-term cooling and --

MR. HSIA: Yes. I was about to say --

MEMBER KRESS: There's a requirement there.

MR. HSIA: -- there are requirements in long-term cooling, 50.46.

MEMBER KRESS: So it's not like --

MR. HSIA: That's a regulation that they have to satisfy. But they don't have to use the method described in --

CHAIRMAN WALLIS: But they have to use some method.

MR. HSIA: Yes. So like I said, when they chose or they cannot use this Reg. Guide methods, they can come up with their own through experiments, through tests, and then we need to evaluate -- assess that.

MEMBER KRESS: They have to satisfy you guys that --

MR. HSIA: Absolutely.

MEMBER ROSEN: And then would you come talk to us about that, if that unlikely event occurred, someone chose to do it their own way?

MR. HSIA: I would like to ask one of my colleagues at NRR if that's -- that's a regulatory issue. If they come in, you are going to issue an SER. Do you come in front of ACRS? I don't -- I'm not sure they come to you for every plant they come in for -- with different methods.

MEMBER ROSEN: Well, it seems reasonable to me that if you're asking for us to agree that this general method should be applicable to everybody -- and we do --

MR. HSIA: Right.

MEMBER ROSEN: -- and somebody else chooses another method, you ought to come in and ask us whether or not the other method is --

MR. HSIA: Well, one scenario could be if that method, when they reviewed the alternative methods, they will still check based on this method to see if they are compatible, if they're similar. And if they find there are large discrepancies, they believe they may choose to come in front of the ACRS.

But if they conclude it's a different method but it's very similar, and it's technically sound, they may not come in front of ACRS.

MR. ARCHITZEL: I guess just for going forward, and a future plant would come in using this, we would review it like Tony is saying. And you'd review when the SER came forward for that plant in the

ACRS. And if an issue arose to that, you'd hear about it, you know, or you'd see it in the SER.

For the existing plants, the backfit comes to play -- and not necessarily all of the positions in the Reg. Guide would be imposed on the plants that are out there. There are selected positions that would be imposed.

CHAIRMAN WALLIS: So you're saying backfit comes to play, because at the end of this Guide it says, "No backfitting is intended or approved," or something.

MR. ARCHITZEL: That's right. So as we go forward, we're not allowed to backfit provisions in this Reg. Guide without going through --

CHAIRMAN WALLIS: Well, it just seems to me that --

MR. ARCHITZEL: But we will use it --

CHAIRMAN WALLIS: -- it may well be that backfitting will have to occur as a result of studying this issue.

MR. ARCHITZEL: But the current plan is to ask if -- for the current plants, ask them for information. And that's not exactly a backfit. They have to do an evaluation. So it's the way the generic communication process works.

CHAIRMAN WALLIS: It's putting off today when they have to do something, it seems to me.

MEMBER ROSEN: Yes. But it may not be a backfit. It may be -- because they have to provide long-term cooling.

CHAIRMAN WALLIS: Yes.

MEMBER ROSEN: And that's the field upon which the agency issued a license.

CHAIRMAN WALLIS: Yes.

MEMBER ROSEN: And if it's now found that the long-term cooling is threatened, or not likely, then it's not a backfit for them to fix it, so that they restore long-term cooling.

MEMBER KRESS: It's a backfit, but they don't have to do a regulatory analysis.

CHAIRMAN WALLIS: It just bothered me to state that no backfitting is intended. It may well be that backfit is the right thing to do, so it's -- dismissing backfit out of hand is not -- didn't seem to me appropriate. Perhaps we'll get to that later on.

MR. HSIA: Okay.

MEMBER ROSEN: You don't need a cost-benefit analysis, a 51-09 analysis, to --

CHAIRMAN WALLIS: But if you don't meet

the regulations for long-term cooling --

MR. HSIA: If you don't meet the regulations, that becomes a compliance issue.

CHAIRMAN WALLIS: Right. You must do it.

MR. HSIA: Right.

CHAIRMAN WALLIS: Okay. So perhaps we should go on, then, from there.

MR. HSIA: Okay. Viewgraph 5 is a brief history. We were here, briefed the subcommittee back in February '03. As you can see, several of the actors have changed. I wasn't here at the time and neither was T.Y. As a matter of fact, our able staff member is now working for -- for you now, ACRS staff. So, but T.Y. is as competent as B.P., so I'm very pleased.

So at that time, we were here, and so was NRR. They discussed GSI-191 and the plans for -- they have issued a bulletin since then, and they are planning to issue a generic letter early next year.

The draft Reg. Guide at that time was called DG-1107 -- was issued for public comment from February to April. And we have -- T.Y. will discuss the resolution of those comments.

CHAIRMAN WALLIS: I'd like to ask you about resolving public comment. We're going to get to this in detail. I read the Guide, and I had almost all of the same comments that the commenters had, even though you've already addressed them, you say.

So it's a bit of a puzzle. Are public comments resolved simply by you saying, "We've resolved them," or do you have to go back to the public and show that you have answered the question? I mean, are you like the politician who gets one question and answers it with something else, or answers it with something which doesn't really answer it? What's the assurance that this resolution really answers the comments in an effective way?

MR. HSIA: Are you saying, how do we get back to the comment --

CHAIRMAN WALLIS: No. You say you have resolved public comments. I mean, are you the arbiter of whether or not you have answered the comments effectively?

MR. HSIA: In a way, yes, we are. We are doing the best we can to say, "This is how we plan -- how we propose to resolve the comments." That's why we're here today.

CHAIRMAN WALLIS: Okay. Check on whether or not you have done this right. It's your own professional --

MR. HSIA: Correct.

CHAIRMAN WALLIS: -- integrity and values, and so on, or maybe the ACRS.

MR. HSIA: Exactly. That's why we're here today as well as this is a public meting. If any public here wants to say, "Hey, you didn't answer my question" or "I don't agree" --

CHAIRMAN WALLIS: Okay. That's so they could come back.

MR. HSIA: Yes.

CHAIRMAN WALLIS: Okay.

MR. HSIA: Yes.

MEMBER KRESS: That's the way you always did it.

MR. HSIA: Yes, correct.

MR. BANERJEE: May I just make a comment here, Mr. Chairman. As I understand, the process is when a rule is proposed or a Reg. Guide is proposed, you send out for public comments. When the comments are received, the staff members analyze the comments. And then, when you finalize any document, it goes back out again with your detailed analysis of each comment and the response that the staff is proposing.

And if there is any serious problem then, then the public comes back, and either in the form of a petition or in the form of a letter to the Commission -- so then the -- the process is very clearly marked, and it's a cycle.

So the way I understand right now, the staff is coming in front of the subcommittee here to tell their plan to resolve the public comment. If you have any serious doubts or anything, then the staff will go back and then make corrections before they go out for their final product.

Isn't that correct, Tony?

MR. HSIA: That is correct. And you can see from the fourth bullet on this viewgraph we're here today, and we are -- to make sure we're not -- because we say this is not a backfit. That's why CRGR has -- we'll have a meeting with them later on this month.

And as you can see, we are coming back; you have another shot at us. I don't mean literally, but --

(Laughter.)

CHAIRMAN WALLIS: You want a letter to -- it seems to me you want a letter in September.

MR. HSIA: After September 11th, yes.

CHAIRMAN WALLIS: That's where if we have still comments, or we think you haven't --

MR. HSIA: Yes.

CHAIRMAN WALLIS: -- the comments, we say so, and then you have another shot at resolving them, right?

MR. HSIA: Correct. We'll make another attempt, I would say.

CHAIRMAN WALLIS: But you're going to issue a 903 anyway?

MR. HSIA: We would like to. But obviously, if there's issues we cannot resolve, that's not going to happen.

CHAIRMAN WALLIS: Okay.

MR. HSIA: And that ends my part of the presentation. I would like to turn it over to T.Y.

DR. CHANG: My name is T.Y. Chang, Office of Research.

This slide shows that once the majority of the revisions are made, it's made in the PWR sections, because this is the intention of issuing this Reg. Guide. However, we tried to make sure that the PWR sections and the BWR sections are consistent with each other whenever it's appropriate.

Another thing is Reg. Guide 1.1 has been subsumed into this current version. So only for some older plants they have to refer back to this Reg.

Guide 1.1. For future plants, they refer to Reg. Guide 1.82 now for the NPSH issue.

Next slide, please.

This is a summary of the public comments we received. We received 89 comments from seven commenters -- four utilities, Westinghouse, NEI, and one individual.

And the last bullet, in descending order, are frequencies of comments raised. We have -- the first one we received 13 comments, and the second one eight comments, and so forth. We are going to go each one now.

Next slide, please. Yes?

MEMBER KRESS: Just a general thought. It seems to me every time we review some of these draft Reg. Guides and rules, and you guys go out for comments and then get them back, 99 percent of the comments come from industry -- utilities, Westinghouse, NEI. Once in a while we get one from the Union of Concerned Scientists, and sometimes an individual.

But is that an appropriate -- you know, all we're doing is talking to the utilities, it seems like. How do you distribute? Do you just put in the Federal Register Notice and then --

DR. CHANG: Yes, it's announced in the Federal Register Notice. Anyone can send in their comments.

MEMBER KRESS: Anybody can that wants to.

DR. CHANG: Right.

MEMBER KRESS: This individual, is that a public citizen, or did it -- or do they belong to some organization?

DR. CHANG: I think he's a consultant.

MEMBER KRESS: Consultant.

DR. CHANG: Yes.

MEMBER KRESS: It always bothers me that we don't seem to get real public input to these things. We seem to always be -- hear from the industry only.

MEMBER ROSEN: People don't vote either.

MEMBER KRESS: Yes, that's true.

MEMBER SIEBER: Well, people don't get a subscription to the Federal Register. You know, you get about this much stuff, two feet high, every day, because there's a lot of agencies, a lot of stuff in there.

MEMBER KRESS: I just wondered if there was a better way to do it, but I can't think of one.

CHAIRMAN WALLIS: Well, I would -- yes, I would think not so much the public, but sort of a technical savvy community.

MEMBER KRESS: Yes.

CHAIRMAN WALLIS: So if somebody who is not part of the system of regulation and licensing, and all of that, were to read this, would it seem believable? Trying to get some view which isn't -- doesn't have a motive, profit motive or something. Are we the only people like that?

MEMBER KRESS: I don't know.

MEMBER RANSOM: Well, the Union of Concerned Scientists, usually they have a motive, too.

MEMBER KRESS: No. They have an agenda. Sometimes you can believe them; sometimes you can't.

DR. CHANG: Okay. Let me go on.

CHAIRMAN WALLIS: Well, we've made this comment many times. I think it is a weakness in the system. These comments always come back from interested parties trying to do something for their own benefit.

DR. CHANG: I think that's human nature, right?

Next slide. This --

CHAIRMAN WALLIS: I don't know what benefit I'm getting out of being here.

(Laughter.)

MEMBER KRESS: What was the comment -- are you going to go over these comments later?

CHAIRMAN WALLIS: Yes.

MEMBER KRESS: Okay.

CHAIRMAN WALLIS: Let's go on.

DR. CHANG: The next one is about conformance issue for current plans. We've got 13 of them.

CHAIRMAN WALLIS: I think this is an important issue.

DR. CHANG: Yes. For instance, the first comment is how Reg. Guide will be used for the current plans. We mentioned that there is no intention for backfitting for the current plans. It's only used as simply for the evaluation of the long-term cooling of the ECCS.

CHAIRMAN WALLIS: No, I'm not sure you can use the Reg. Guide for evaluation methodologies, because my impression is the Reg. Guide says, "Go and do this. Go and do that. Go and see" --

DR. CHANG: Well, we have --

CHAIRMAN WALLIS: It doesn't say anything about the existence of a methodology for doing it.

DR. CHANG: We have staff positions there, too. Okay? Not only acceptable methods.

CHAIRMAN WALLIS: It all seems so vague. It says, "Go and calculate the debris transport." It's not clear that anybody knows how to calculate the debris transport.

DR. CHANG: Well, this is not the intention of the Reg. Guide. We have not tried to be prescriptive that people have to follow those steps.

CHAIRMAN WALLIS: Do you see the problem I have? You're evaluating methodologies which probably don't exist.

MR. HSIA: If I may jump in. Bruce, please. Welcome. Go ahead, Bruce.

DR. LETELLIER: Well, first of all, I don't think the Reg. Guide can be applied without a knowledge of the historical research base that goes along with it. And there has been an attempt to document the supporting references. And one suggestion has been that we add citations in the appropriate sections, so that it's not difficult to reconstruct that history for a first-time user.

MEMBER KRESS: That would seem to be helpful to the reader.

DR. CHANG: Yes. I think that that's the intent of the second part of my presentation is to try to describe our staff positions in the Reg. Guide and the so-called acceptable methods. And then, Bruce will go into specific ways of how to apply those methods in real cases.

So I think that will address your question. Just be patient with us.

CHAIRMAN WALLIS: Well, I don't think it helps at all. If you read the Guide, you just pick up at random a section, all insulation, blah, blah, blah, blah, blah, blah, blah, you know, great list of stuff, should be considered the debris source. Models or experiments should be used to predict the size of the postulated debris.

DR. CHANG: That's one of the acceptable methods. They can choose to be conservative, to assume the worst --

CHAIRMAN WALLIS: But all postulation is an enormous amount of stuff.

MEMBER KRESS: Well, they give some guidance in the Los Alamos report on how to deal with that.

MR. HSIA: Chairman Wallis?

MEMBER KRESS: I think if you reference the Los Alamos methodology in there, it might help.

MR. HSIA: Chairman Wallis, this is Tony

Hsia from Research.

CHAIRMAN WALLIS: Yes.

MR. HSIA: This Reg. Guide is not meant to be a manual for anybody who wants to assess their plant vulnerability regarding debris impact on ECCS performance. It is, indeed, a guide. In there later on I hope you will see that we -- like you just read, we have guidance here saying, "You shall do this. You should do that. We recommend that."

And many, many of those, if not all, have been documented based -- as a result of previous research and numerous reports, NUREG reports. I just want to mention two very significant ones. One is a knowledge-based report. I'm sure you all have a copy. Another one is an older report, NUREG/CR-6244. Both of those have been peer reviewed, and so this is nothing new, really, to the industry or anybody.

CHAIRMAN WALLIS: Well, see, the problem is I don't know how you got this -- this knowledge base. But I read it, and it's so qualitative.

MR. HSIA: I'm sorry?

CHAIRMAN WALLIS: It describes things, and it describes things you ought to consider. It doesn't say how to do it. It says, "Here's this event in Barseback. This is what happened. Here's this thing in Hyse, Dumphrey, Oktor," or so and so," all these things. It describes it. It doesn't give the impression that there's any way to predict what happened.

MR. HSIA: That part, you're correct. That is early in that report. Later on --

CHAIRMAN WALLIS: What good is it for predicting anything?

MR. HSIA: Later on there are sections into different -- each phase of the accident sequences. There are methods described, a test that was done, and what you can learn from those tests, as well as the analyses that was done, what you can do with those analyses/methods. And that's what we're hoping -- that Bruce will get into that detail as we go along.

CHAIRMAN WALLIS: Okay. So we'll get into that detail later.

MR. HSIA: Right. The point I want to stress right now is both of those reports I mentioned earlier have been peer reviewed, and discussions we have had --

CHAIRMAN WALLIS: Your process must be something like the public comment process, too.

MR. HSIA: Well, public comments --

anybody in the public, peer review, our field industry experts, or a professional engineer that has expertise in this area. There are technical people who took time to really review all of the reports.

And also, we have had several workshops. We have had discussions with the public, with the interested parties. So many of those methods, experiments, analyses, have been discussed before. So I just want to say this is not brand-new to the people who are interested in doing this.

CHAIRMAN WALLIS: I just think when you have a peer review you have to have some sort of -- be clear what it is they're reviewing, for what purpose. And a peer review that says, "This is an interesting document" is one thing. A peer review which says, "This document really explains how to make calculations for something with some kind of accuracy" is a really different kind of peer review.

DR. LETELLIER: I think you're expecting to see predictive phenomenology models that simply don't exist.

CHAIRMAN WALLIS: That's right. Well, in order to do what you want done in the Reg. Guide, I have to have those.

DR. LETELLIER: I think the objective of

the Reg. Guide is to make a conservative, yet realistic, approximation of the various stages of the accident sequence.

CHAIRMAN WALLIS: Okay. Maybe you'll make that case. I want to let you get on to it.

DR. LETELLIER: I hope so.

CHAIRMAN WALLIS: Yes. I'm sorry to interrupt you, but you were talking about this conformance issue.

DR. CHANG: Right, the first bullet. And then, the second comment on the conformance issue is some current plans have different designs as compared to the ones we mention in the Guide. For instance, the multiple --

CHAIRMAN WALLIS: Do any of them have floors that slope away from the screens? That seems a strange requirement.

DR. CHANG: Yes. I don't know whether -- are there --

DR. LETELLIER: Not to my knowledge. In fact, there are very -- perhaps one or two at the most that actually have designed drainage systems to return water to the screen.

CHAIRMAN WALLIS: In any shower stall or anything, the drain is at the bottom of the slope, not on the top of the hill. It seems a very strange statement in there. So they certainly have different designs as compared to the RG position in terms of the slope of the floor.

DR. CHANG: Yes. We tried to say that --

MR. ARCHITZEL: But there are some that have that, and -- but the normal sump would be the lowest point. The accident sumps, there's quite a few that do have the --

CHAIRMAN WALLIS: They do.

MR. ARCHITZEL: -- slight rise.

CHAIRMAN WALLIS: Okay.

MR. ARCHITZEL: Certainly, a lot with curbs.

CHAIRMAN WALLIS: Okay. So they do.

MEMBER ROSEN: This is not an accident, then. The curbs are there for a reason.

CHAIRMAN WALLIS: This means that when there are spills of water it goes on the floor and is not drained because the highest point is --

MR. ARCHITZEL: No, there's a normal sump that would be the lowest point in the drain, different sumps.

CHAIRMAN WALLIS: Oh, okay. Thank you. That's good. That helps.

MEMBER KRESS: Multiple sumps don't seem like they're any different to me than one sump. It's just like a bigger one sump. Is that --

DR. CHANG: Well, you have two independent sumps in different locations. I think usually --

MEMBER KRESS: Yes, but there's a common cause failure, and that's the debris goes to both of them. It's like just having one sump that's a little bigger than this one.

MEMBER SIEBER: If your containment is compartmentalized --

DR. CHANG: Right.

MEMBER SIEBER: -- then you have a different debris field for one --

DR. CHANG: That's far away from each other.

MEMBER SIEBER: -- than you have from the other.

MEMBER ROSEN: You have a longer transport there for the one -- distance to one sump than the other, and that may be important.

MEMBER KRESS: I can see that being important.

DR. CHANG: But our intention is that this Guide is not just for current plans. It's for future plans as well. So we just pointed out those possibilities for the consideration if future plants are being designed.

The third comment is the Reg. Guide appears to favor a particular configuration of screen because of the cartoons we have in the Reg. Guide. We tried to clarify, to change the caption, saying that those are conceptual features -- to indicate that they are conceptual in nature.

CHAIRMAN WALLIS: So this Reg. Guide will be used in the first response here, the evaluation of current licensees, methodologies, long-term recirculation cooling, and this will be, then, accompanying some NRR effort to make sure that the plants actually have those capabilities.

DR. CHANG: Oh, yes. Oh, yes.

Ralph, do you want to talk about the NRR continuing program on this issue?

MR. ARCHITZEL: Yes. We were here before at the same time you were. We currently plan -- last time we were here we had a Generic Letter in front of you, and you said, "Put it out quickly." We ended up splitting that after we met with you into a bulletin with the interim actions and a Generic Letter to follow.

The Generic Letter will require evaluations and request information to show that they can meet this deterministically. But before -- or what they're going to do that to is not this Reg. Guide. It's going to be -- at the present plan, we plan on looking at industry evaluation guidelines, detailed guidelines, in terms of how you do these evaluations. So that there's more of a --

CHAIRMAN WALLIS: But that isn't available yet, is it?

MR. ARCHITZEL: It's not available yet. The last plan from NEI we heard was September of this year, and that may not make that date.

We would evaluate that and write an SER, and that guidelines it. We're looking towards the middle of next year to complete our evaluation of those guidelines.

CHAIRMAN WALLIS: Well, I guess from the public point of view, the issue is how long it's going to take to resolve what's been a long-standing safety issue of impossible importance.

MR. ARCHITZEL: NEI approved guidelines are a while off yet. But this would be the yardstick we would use to evaluate those guidelines. This Reg. Guide is used as the evaluation of --

CHAIRMAN WALLIS: Okay. So it's a yardstick. So it better be -- better have units on it, right?

MEMBER FORD: Since you don't have a predictive methodology -- I mean, for instance, you cannot predict why Barseback or Gundremmingen, these other stations which have seen pump blockage occur, that a whole list of various variables -- mesh size, debris sources, etcetera, where you have no way of quantifying whether that particular lineup or parameters will give you a real -- give you a problem down the sump.

So following on from the previous question, what is your criteria for success or compliance by the utility to this Reg. Guide? This Reg. Guide just lists a whole lot of, "Hey, look out for the slope of the floor, mesh size," etcetera, etcetera. You're just listing all of the variables, but you're not giving any criteria as to the well, which are the most important ones.

What defines compliance to the Reg. Guide? Do you understand what I'm saying? There's no quantification.

DR. LETELLIER: Well, let me attempt to clarify. First of all, the units, the calibration of the yardstick, are based on NPSH margin. That is the ultimate condition of compliance -- whether or not a given licensee can accommodate a certain fraction of debris transport and still provide long-term cooling as defined by --

MEMBER FORD: But there is no algorithm relating NPSH to all of these other variables.

DR. LETELLIER: Well, when we say that there are no predictive models, in large part we're referring to the transport step. Now, we do have test data that describes debris generation. We have test data that describe head loss when the debris arrives on the screen. And those are predictive; they're based on empirical correlations and on some semi-empirical theory.

So the various pieces have been quantified to the level of detail that was possible with the resources that we've been given in the past few years. The lack of predictive capability comes in in the variability of input parameters.

We're not certain exactly what the conditions of a given accident will be, and we're -- we don't have a capability to predict the transport fate of an assumed particle of debris.

MEMBER FORD: That's right.

DR. LETELLIER: And so, therefore, we're using the test data to make conservative engineering judgments about the connections between each step of transport.

MEMBER FORD: I guess I'm putting myself in the shoes of the utility, and saying, "Okay. I've got to meet a certain NPSH quantitative criteria." But I have no idea what -- the things I should be controlling. And I've got this great big list of things, and if you look at your report, the Los Alamos report, there's a huge number of interrelations which no one -- no one -- understands or can predict.

DR. LETELLIER: Well, I --

MEMBER FORD: So is there going to be a big EPRI program to put a -- to qualify this, so they can react proactively to this problem?

DR. LETELLIER: I'd prefer to respond to a specific question regarding lack of predictive capability, and that way we could show you the supporting evidence that would help you make judgments.

MEMBER FORD: Okay.

DR. LETELLIER: But, in general, let me say that the guidance is intended to demonstrate acceptable methods that range all the way from

100 percent damage, 100 percent transport, 100 percent blockage, all the way down to phenomenology-based engineering judgments about what fractions would actually participate in each step of the process.

Of course, the more detail that you have to take credit for, then the more responsibility you have to baseline your judgments on data, testing, and evaluation programs.

In fact, when the comment was made by Dr. Wallis about 100 percent inventory being overly conservative, in fact, that was the resolution path taken by the BWRs. As a matter of practicality, they had enough space to redesign their strainers to accommodate that amount of material.

CHAIRMAN WALLIS: Well, it couldn't be all the material in the air handling units.

DR. LETELLIER: They designed their strainers to accommodate all of the insulation, thermal insulation, in containment.

CHAIRMAN WALLIS: Well, 13,000 cubic feet? That's this room full. I don't know, maybe more than this room full. Yes, more than this room full. I can't believe it, that you're going to put all of that on your strainer.

DR. LETELLIER: You're referring to filter media in the air handling units and --

CHAIRMAN WALLIS: It's in your -- this technical basis. I just -- it just struck me.

DR. LETELLIER: Well, keep in mind --

CHAIRMAN WALLIS: I don't know what this is, and why it's in the air handling units. But it's in your report that it's there.

DR. LETELLIER: Keep in mind that when you consider debris generation, you have to examine the potential source locations. And then you assess the targets that might be impacted by the damage, so --

CHAIRMAN WALLIS: I have no idea where the air handler units are relative to where the LOCA might be or why --

DR. LETELLIER: And it may vary --

CHAIRMAN WALLIS: -- the stuff might fall out in a steam environment or not. But that's something that presumably is going to be calculated using your methods.

DR. LETELLIER: The locations may vary widely.

CHAIRMAN WALLIS: Yes.

DR. LETELLIER: In fact, and it -- I think it's listed there for completeness sake. If a particular licensee knows that their air handling units are vulnerable to impingement, then that represents a potential debris source that they have to accommodate.

CHAIRMAN WALLIS: I wonder if they have any clue about whether they're vulnerable to a shockwave.

DR. LETELLIER: By inference of proximity, and based on the test data for damage zones for different types of debris ranging from bare fibrous insulation all the way to encased stainless steel jackets, I think that the industry does have a good impression of what the damage zones are.

Now, that's not to say that the database is entirely inclusive. We were able to test the predominant materials, the predominant insulation types. But there are certainly others.

CHAIRMAN WALLIS: Well, that's what's -- I do see you have these -- you have -- I know you have some good tests on certain kinds of insulation on pipes. But this air handler unit, where is it? I'm sorry to keep on this, but because this is a huge number in your report -- 15,000 cubic feet.

Now, is this in sheets of loose stuff in some kind of -- like in my domestic heating system, hot air system? It's a very, very flimsy filter.

DR. LETELLIER: But in general --

CHAIRMAN WALLIS: The slightest thing can break that up.

DR. LETELLIER: That's true. But in general --

CHAIRMAN WALLIS: Is that what they're like?

DR. LETELLIER: Yes.

CHAIRMAN WALLIS: Then, why are they considered?

DR. LETELLIER: But in keeping with your analogy of a home furnace system, you know that those materials, those fiberglass panels, are encased in mechanical equipment. They are shielded, in a sense, by the sheet metal.

CHAIRMAN WALLIS: Well, I don't know how they are in the plant.

DR. LETELLIER: In fact, that's true in the plants as well.

CHAIRMAN WALLIS: So that the utility has to look very carefully at all of those things, like say the air handling units, and say, "Gee whiz, my filters are not very well protected. I'd better do something about it," or something?

DR. LETELLIER: That's true. Ultimately,

the --

CHAIRMAN WALLIS: Do all of these assessments and --

DR. LETELLIER: -- judgment falls on them. But keep in mind --

CHAIRMAN WALLIS: Eventually, maybe if they don't do it, some NRC inspector will walk around, if they have a walkaround in site containment, and say, "Gee whiz, I can see a lot of loose filter material up in that air filter. This looks like something that might give a problem with sump block issue at" --

DR. LETELLIER: Well, the guidance also serves the purpose of audits for the regional inspectors. And so the Reg. Guide provides consistency between the NRC approach and the industry's perspective as well.

Keep in mind that the assessment of a given vulnerability may be as simple as proximity. This is outside the damage zone. Therefore --

CHAIRMAN WALLIS: We're going to move on.

DR. CHANG: Yes.

CHAIRMAN WALLIS: But you're putting an awful lot of reliance here on the ability of each one of these licensees to make a proper assessment of all the sources of debris and what will happen to it.

MEMBER ROSEN: That's correct. When we get the guidance from NEI --

CHAIRMAN WALLIS: Right. We have to get some guidance. We haven't got it yet.

MEMBER ROSEN: No, we haven't got it.

CHAIRMAN WALLIS: We have no idea if it's going to be adequate.

MEMBER ROSEN: Well, we will presume that they will do a good job as they do on many things and be proud of it and tell us about it.

I would observe it's 9:15. That's the close of the discussion on the comments, and I don't think we're quite there.

DR. CHANG: Okay. The next issue about overpressure -- in the Reg. Guide, we mentioned that for the ECCS and containment heat removal systems, they should be designed such that the pumps have available sufficient to the NPSH.

Assuming no overpressure from -- as compared to that -- before the LOCA -- this is a conservative assumption -- the comment is that this is not consistent with the licensing basis for certain subatmospheric containment plants, because in those plants they have vacuum under the normal operation condition.

Our response is that the original position stays with change -- with some modifications. The modification is that we said for subatmospheric containments, this guidance should apply after the injection phase has terminated. Prior to termination of the injection phase, the analysis should include conservative predictions of the containment subatmospheric pressure and sump water temperature as a function of time.

MEMBER KRESS: Why should you give subatmospheric containments this advantage but not give it to the other plants? Why shouldn't an ordinary large dry PWR be able to take the containment pressure prior -- after injection also? If it's good for one plant, shouldn't it be good for the other?

DR. CHANG: Well, I think it's consistent. We are trying to be on the conservative side.

MEMBER KRESS: Yes, you've been consistent. The subatmospheric plants have been given --

DR. CHANG: For subatmospheric plants --

MEMBER KRESS: -- an allowance for overpressure.

DR. CHANG: Prior to the switchover, they have to assume conservative predictions for pressure and water temperature as a function of time.

MEMBER KRESS: Yes. But it seems to me like if you're going to let the subatmospheric containments do that, you ought to let other containment types do it also.

DR. LETELLIER: To be honest, I'm not certain what additional benefit that really adds. If you look at the words that -- we're talking about the switchover to recirculation, between injection and recirculation. And after the injection phase has terminated, the guidance defaults back to the pressure that existed before the --

DR. CHANG: They still have to comply to the pre-LOCA condition.

DR. LETELLIER: In effect, T.Y. was correct that our -- the staff position has not changed, that we're defaulting back to the Reg. Guide 1.1 position, that in order to accommodate a variety of accident scenarios, including loss of containment, it's always conservative to assume the pressure that occurred before the LOCA event.

DR. CHANG: Okay. The next one, the next slide, please, is on the screen mesh size. In the original Reg. Guide sent out for public comment, we have a sentence saying that a site should be smaller than the minimum restrictions found in the systems downstream of the sump, and then later the ECCS or the reactor coolant system components.

The comment is that this may lead to very high head loss for -- in current screens, if you use such a small mesh. And also, it may make the screen areas too large to be practical.

The second comment on the mesh size is someone suggested that the long thin debris slivers may pass axially through the sump screen, and may then reorient and clog the flow restrictions downstream, such that pump seals -- such as pump seals and barriers in those locations. This shall be considered -- this is the comment.

Our response to the first one is that we modified the Reg. Guide to say that the size of the screen pump opening should be determined considering the flow restrictions of systems. We don't say it has to be smaller.

And then, the mesh size is -- if the mesh size is impractical to be fine enough to filter out particles of debris that may cause damage to the downstream equipment, then it is expected that modification would be made to the ECCS pumps, or they can purchase a pump that can handle those small particles.

And on the second comment we --

CHAIRMAN WALLIS: There is a pump that will do this that's easily accessible and --

DR. CHANG: Ralph, do you have any information on that?

DR. LETELLIER: We don't have specific vendor information, but we are aware of pumps that are designed to handle high debris loadings. We're not certain that they're qualified for nuclear applications.

The point is, in the response to this comment, is that the filter screens have a performance criteria. They are there for a purpose -- to protect downstream equipment. And the vulnerabilities of the downstream equipment should be used to define the performance standards.

MR. ARCHITZEL: But I guess to go to a specific example, in the Davis-Besse case, the low pressure safety injection pumps were capable of pumping the fluid that got through the screens. And the high pressure safety injection pump wasn't evaluated, so it is somewhat pump and vendor specific. They did have to modify the high pressure safety injection pumps for this issue.

CHAIRMAN WALLIS: But one of the commenters said that, if these fibers got through, they would tangle up on things like spaces in fuel.

DR. CHANG: Yes, that's the second comment.

CHAIRMAN WALLIS: They'd be tangling up, and they didn't have to be bigger than the opening in order to start tangling up on these. The spaces themselves are sort of filter or screen. So did you respond to that?

DR. CHANG: Yes. I think that's related to the second comment, as I mentioned -- that the last slivers of fiber may pass through the mesh opening axially and get clogged up later on in those small areas like pump seals or bearings.

So we agree with the comment, and we modified the Reg. Guide to say that people have to consider those conditions if they have that in their plants.

CHAIRMAN WALLIS: Well, you just said consideration should be given to the buildup of debris at downstream locations.

DR. LETELLIER: There is currently a research effort in place --

CHAIRMAN WALLIS: Very vague.

DR. LETELLIER: -- for the next fiscal year to look at screen penetration.

CHAIRMAN WALLIS: Well, there's no criterion for anything. I mean, suppose you say, "Yes, I'm going to have my spacers on some of these fuel elements festooned with fiber," so what? I mean, there's nothing here that says how you decide whether or not it's okay.

DR. CHANG: Well, in this case, we just bring this to the attention of people there. This is a possibility.

CHAIRMAN WALLIS: Well, this whole thing is so vague, you've got to consider all of these things. Are we waiting for some guidance?

MEMBER ROSEN: Yes, the guidance from NEI.

CHAIRMAN WALLIS: Is that what we're waiting for?

MEMBER ROSEN: I think that's the key document.

MR. ARCHITZEL: I'd like to point out that NEI guidance deals with the GSI-191 issue. It doesn't deal at all with the downstream blockage effects. No one -- they're not working on that, so this issue, which is, say, blockage in the fuel channels, is not part of that effort.

MEMBER ROSEN: Why not? I mean, isn't that -- the Reg. Guide now clearly says "modified to make that comment."

MR. ARCHITZEL: But I'm not saying the Reg. Guide does. I'm just saying it's not part of their current effort.

MEMBER ROSEN: Okay. So now that we've had that comment from the public, and the staff has looked at it and put it -- modified the Reg. Guide, now it seems to me incumbent on NEI to deal with what's now going to be in the Reg. Guide. Am I correct?

MR. LEHNING: This is John Lehning. I guess it's not incumbent on NEI to deal with what's in the Reg. Guide, but it would be incumbent for each licensee to deal with --

MEMBER ROSEN: Right. Well, yes. And the licensees have delegated that to NEI rather than come up with 59 or 69 different solutions, which is logical. So now it seems to me, I mean, you know, we have a coherent system. We have public comment, you respond, you change the Reg. Guide. The utilities now have to deal with what's in the Reg. Guide or come up with alternatives. They don't have to choose to come up with alternatives.

And they hired NEI to come up with a common method they can use. They set up a task force to work with NEI and to make sure that the guidance comes out the way they think is reasonable and responds to the Reg. Guide appropriately. But, I mean, I'm stunned to think that NEI wouldn't now change the Reg. Guide to deal with this comment, because the Reg. Guide -- change the guidance to deal with this comment, because the Reg. Guide is going to have it in it.

We have an NEI representative here. He could address that. Would you choose to do that?

MR. BUTLER: I don't know what you'd like me to say. I mean --

MEMBER SIEBER: You need to use the microphone.

MR. BUTLER: John Butler at NEI. Our initial effort did not focus on the downstream effects. Part of the difficulty with addressing downstream effects, it's very design-specific, vendor-specific, part-specific. All we could do without an extensive research effort would be to provide some guidance that probably would not go into a lot more detail than the current Reg. Guide point, things that plants would need to look at to ensure that they've accommodated in some fashion.

But the analyses necessary to demonstrate that their system can accommodate materials that pass through the screens is very pump-specific, design-specific.

MEMBER FORD: Could I ask a question? It's more of a procedural and which I don't understand. This Reg. Guide, this NRC Reg. Guide, gives a lot of qualitative requirements -- assess this, consider that.

Now, do I understand from the conversation that has just gone on that now NEI is going to issue a guidance to their utilities as to how they're going to respond to NRC's request for assessment? So NEI is going to give the quantitative answer?

MEMBER ROSEN: Yes, that's my understanding.

MEMBER FORD: Is that true?

MEMBER ROSEN: Rather than each utility doing it themselves, they've come together in a task force, an NEI task force, which has been charged with the responsibility of coming up with a set of guidance for that -- for each utility to use --

MEMBER FORD: Well, it would close the

circle, then.

MEMBER ROSEN: -- to close the circle.

MEMBER FORD: How will NRC approve, if you like, the NEI's quantification of these requirements?

MEMBER ROSEN: I expect, but I will let them answer for themselves, I expect that they'll read it and write an SER saying that's an acceptable way of meeting the Reg. Guide. Is that correct?

MR. ARCHITZEL: Well, it won't be meeting the Reg. Guide. It'll be an acceptable methodology to address this evaluation that would be addressed in the Generic Letter. But it would be an SER.

MEMBER FORD: And how long will it take to come up with these quantitative guidance to your members?

MR. BUTLER: We're still working toward an end of September schedule.

MEMBER FORD: Gosh. If you read this Los Alamos thing here, I'm not an expert in this area, but you're not looking at a three-month research effort to quantify the interactions between all of these variables to meet their qualitative requirements.

Am I being dumb here? Am I missing something?

MR. BUTLER: No, sir. Let me point out

what Bruce pointed out earlier, that you have a choice in assuming a very conservative assumption or taking a more phenomenological approach to -- that requires a little bit more investigation and detail.

What we're attempting to do with the guidance is provide each utility with options in each phase of the event, as to which method they choose to use. If they can accommodate a very conservative approach in terms of the answer that that gives, that is the simplest and most direct way to get an answer.

In other instances, they will need to provide -- go with a more phenomenological approach, still probably using some conservative assumptions.

MEMBER FORD: Okay.

MR. BUTLER: Because there is not a lot of detailed phenomenological research available that they can use. And there's a large variability in the designs that it would be very difficult to do that on a generic basis.

So the level of detail that they use in their analysis, the level of conservatism they use in their analysis, will be up to each individual plant to meet their needs.

MEMBER FORD: Okay. Thank you.

MR. HSIA: This is Tony Hsia from

Research. I would like to add that the advantage of an issue this -- with such a long history was that industry has done quite a bit already, because we -- that was evident to me when we attended the workshop back in July in Baltimore.

Their plans were to perform analyses to evaluate the debris generation. Their licensee will perform analyses and attempt to figure out a washdown and transport -- washdown from -- you know, with container spray of the debris and transport debris.

And I was impressed to see there was one plant who actually had a very extensive plant walkdown and documented why each room has possible debris. That's the -- later on you will see, when we get into detail, that's -- as it turned out, the NRC and the industry has evolved to really look at this whole thing, and back up a step and say you've got to figure out debris generation, you've got to figure out how to move that debris, whatever you have, from your location down -- washed down to the sump. And this transport in the sump, then eventually the possible blockage of screen and suction strainers.

So that's the direction everybody is going to. And I hope when we get into the detail, you'll be able to see it better.

And I'd also note that Bruce is correct when he said there is no method, he really -- I believe he really meant to say there is no integrated predictive method. In other words, you don't have a code -- let me just put a name out there like a revised RELAP that can include all the debris and predict where they're going to go, and with what kind of force they're going to strike each object. We don't have that tool.

So the best we can do is right now, using codes like RELAP, like MELCOR, at different phases of the accident, and then incorporate that with the test, the knowledge we have gained from experiments on how -- what kind of debris, what size, what kind of debris we'll have, and combine that with the plant-specific configuration. With that all put together, that's the best we can predict today.

So what he meant is there's no integrated simple tool that can give it a solution just by punching in the numbers.

DR. CHANG: Okay. Next slide, please.

The next concern is on the leak before break for the resource. The comment is that Section C.1.3.2 requires application of large breaks in essentially all locations in the reactor coolant system for regeneration.

This is consistent with 10 CFR 50.46. This is for the calculation of ECCS capability, long-term capability. You have to postulate the most severe postulated LOCAs. But in our case, for the sake of the generation of the worst debris, we used the same approach as 50.46. In other words, they have to consider the most severe postulated LOCAs.

The comment is that this is not consistent with the leak before break position of GDC 4. Our response is there is no change after Reg. Guide. The staff position was documented in a letter to the Westinghouse Owners Group in 2000. The position is that LBB is not applicable to LOCA-generated debris.

However, the staff acknowledges that we have received an NEI request to consider alternatives to a double-ended guillotine break for debris generation. For instance, they postulated maybe we can use the fraction mechanics to predict a certain size of break instead of the double-ended guillotine break.

This is something in between the two extremes. One is the double-ended guillotine break; the other one is the leak before break. So it's sort of a compromise suggestion.

And this is a policy issue which may result in changes to break size used for debris generation. So after we reviewed -- finished reviewing this alternate, what is the status on that now, Ralph?

MR. ARCHITZEL: The last was NEI was going to provide some supplemental material to their earlier application. And once we get that, we plan to go with an ANSI policy paper up to the Commission.

DR. CHANG: Okay.

MEMBER KRESS: Let me ask a technical question, perhaps to Mr. Letellier. How do you pronounce your last name?

DR. LETELLIER: Letellier.

MEMBER KRESS: Oh, you pronounce the R.

DR. LETELLIER: It's been Americanized.

MEMBER KRESS: Is the quantity, size, and transportability of debris in the general locale of the break a strong function of the break size, pipe size?

DR. LETELLIER: The volume of debris is definitely a strong function of the pipe and size. And the correlations are -- have that as a key parameter -- the pipe diameter.

MEMBER KRESS: Okay.

DR. LETELLIER: The amount of debris generated is also a strong function of the damage pressure for the given debris type. As I mentioned, bare insulation to jacketed material to reflected metallic. All of those respond differently.

MEMBER KRESS: Okay. That bears on how I think about this large break LOCA and leak before break issue.

CHAIRMAN WALLIS: I think it's important in big LOCA -- a big LOCA is a really big debris source.

MEMBER KRESS: Yes. But it has a very low probability.

CHAIRMAN WALLIS: That's where the argument is about the leak before break.

DR. CHANG: All right. The next slide, please.

The next comment is on the partially submerged screens, and it's a failure criteria. In the original Reg. Guide sent out for public comment, we have a statement that credit should only be given to the portion of the sump screen that is expected to be submerged at the beginning of recirculation.

Allowance should be provided for circumstances in which the level of submergence changes substantially following the beginning of recirculation. This is the comment on our statement.

The example cited is it's like using an ice condenser containment, that continually the ice melts and you increase the water level. So if you specify that they have to stick with the water level at the beginning of the switchover, then this is not considered there.

The staff position has been modified in the Reg. Guide to say that for partially submerged sumps credit should only be given to the portion of the sump screen that is expected to be submerged as a function of time. So we added this as a function of time. It's not at the switch of -- switchover time.

Pump failure should be assumed when the head loss across the sump screen is better than half of the submerged screen height, or the NPSH margin. This addresses Dr. Ford's question about there is no failure criteria there. This is the bottom line.

Okay. And originally we have I think -- in the revised version, we have one-half of the pool height. Now we change it to the submerged height. It's because in some designs they have a curb there. A curb effectively is a block of the screen, so you have to count the height without the curb.

Next slide, please.

MEMBER KRESS: That wording is a little strange to me. You're saying that you should assume the pump fails when the head loss across the screen is greater than one-half of the head loss you would get to exceed the net positive suction head origin, or what? I don't -- I'm not --

DR. CHANG: Now which --

MEMBER KRESS: I'm looking at the last sentence of your response. It's just -- I'm trying to read it and see what it actually says.

DR. LETELLIER: Those are two separate criteria. One is the standard NPSH consideration of cavitation at the pump inlet, at the impeller location. You can't violate that margin.

The other criteria is actually a consideration of passing of volumetric flow through the debris bed. The only driving force available is the static head of the water that's sitting in the pool. That's the only way to supply water to the sump well.

MEMBER ROSEN: It would just be a dam that's holding back all --

DR. LETELLIER: That's right.

MEMBER ROSEN: -- the water.

DR. LETELLIER: It's a dam essentially. And on average, your static head is about one-half the pool depth minus the curbing. And so there are actually two separate failure conditions, and I would propose we add the words "whichever is less," the minimum of --

MEMBER KRESS: I just think that sentence needs to --

DR. CHANG: Yes, whichever is less. That's the intention.

CHAIRMAN WALLIS: Actually, they work in combination that -- that you get some drop-in head across the screen, and then you have to worry about NPSH from that lower head. So the two really act together, don't they? They're not independent.

DR. LETELLIER: It's actually the minimum of the two. Whichever is lower will be your threshold.

CHAIRMAN WALLIS: You have to add the two together. Anyway, you'll sort it out.

DR. CHANG: Yes. Next slide, please.

The next comment is on the one-eighth thin bed value. I think we are going to go into the thin bed later on, but the comment is that there seems to be no supporting technical basis to have the number one-eighth of an inch there in the Guide.

And we made it clear that there is some technical basis in this new --

CHAIRMAN WALLIS: So it's not a magic number. It hasn't really any basis except that it worked for certain physics for certain kinds of material. Nothing magic about an eighth of an inch.

DR. LETELLIER: It is based on test data.

CHAIRMAN WALLIS: No. I mean, it's --

DR. LETELLIER: A bed that's thinner than that will fail.

CHAIRMAN WALLIS: It depends on the screen and the kind of debris and all sorts of things. But anyway, we'll get to that later.

DR. CHANG: Next slide, please.

The next one is on the adequate protection after sump on --

CHAIRMAN WALLIS: This one is an easy one, I think.

DR. CHANG: This is an easy one, I hope.

CHAIRMAN WALLIS: We can pass over this one, unless anyone has a question about it.

DR. CHANG: The next one? Want to skip this one?

CHAIRMAN WALLIS: Well, I had a comment on this.

DR. CHANG: Oh, you have a comment.

CHAIRMAN WALLIS: In reading the Los Alamos basis -- knowledge basis, it seemed to me that CFD is shown to qualitatively simulate some of these things. But it wasn't really an analytical tool yet.

DR. LETELLIER: Again, the use of CFD codes is to provide engineering information about water velocities and what the transport pads would be. CFD is not sufficient for predicting debris behavior in water. Those models don't exist, and it was not the intent to develop that -- those models.

CHAIRMAN WALLIS: Well, it says analytical -- it's an acceptable analytical approach to predict debris transport. And you're saying it can't do it, so --

DR. LETELLIER: Well, we should clarify that to say when used in combination with test data.

CHAIRMAN WALLIS: Ah, okay. Well, good. Thank you.

Yes. This earthquake one is probably okay, too.

And then we go to slide 17, size of the ZOI. Presumably, Los Alamos has ways to estimate the ZOI that answer this public comment on page --

slide 17.

DR. CHANG: Well, our position is that the ZOI should be consistent with the risk-specific damage pressure. In other words, it should extend until the jet pressure decreases below the experimentally determined damage pressure appropriate for each specific debris source. So this is how it is decided -- the size of the ZOI.

DR. LETELLIER: Specifically, to answer the question directly, to do the zone of influence correlation scale with operating or design pressure, the answer is no. The test data don't exist in a comprehensive fashion. What does exist are zones of influence as a function of damage pressure for the BWR tests that were performed as part of the BWR resolution.

There were limited two-phase blowdown tests conducted as part of this exercise, but not in a comprehensive fashion. What we've done is to account for the difference in the thermal hydraulic conditions and compensate for the difference in energy by reducing the damage pressures. Where for a steam jet, bare, unprotected fiberglass might fail at a damage of 10 psi, we now suggest using a damage pressure of 6 psi.

CHAIRMAN WALLIS: This is a stagnation pressure or what?

DR. LETELLIER: That's right.

CHAIRMAN WALLIS: Okay.

DR. CHANG: Okay. Last slide on the public comment is some samples of other comments. One is on the definitions of NPSH. The one we had in the Reg. Guide before probably isn't too clear, so we quoted the definition from the ANSI document. So it's word by word. It's quoted there.

And the second comment is about the chemical reactions in the pool.

CHAIRMAN WALLIS: I have a comment on that. I mean, all you're considering is the chemical reactions producing precipitate. But on page 120 of the knowledge base document, it speaks about interaction of high pH water with zinc and aluminum surfaces producing hydrogen. And then, later on, on page I31 or 131, it talks about the generation of hydrogen from high pH water.

Now, I've made this point before. When you have bubbles produced on these particles, then you get flotation of the particles. So there are chemical reactions occurring in the pool. There's a continuous bubbling and flotation, rather like the notorious tanks at Hanford.

And this is going to change the floatability of the debris. And this doesn't seem to be considered at all. I mean, I've made this point three or four times in the past, and no one has ever put it into any Reg. Guide or --

MEMBER ROSEN: Isn't it a conservatism not to consider that? I mean, if the particles --

CHAIRMAN WALLIS: No. Because you have your heavy particle down at the bottom. They throw it away, because it settled.

MEMBER ROSEN: Right.

CHAIRMAN WALLIS: But if it now reacts with gas and makes bubbles, it floats up and gets transported.

MEMBER ROSEN: Right. But it never settles down low enough to go into the pump.

CHAIRMAN WALLIS: It does, because the bubbles fall off essentially. It rises to the surface, the bubbles release, and it falls down again, and goes through a cycle of progressing along and flotation --

MEMBER ROSEN: Well, ultimately, it comes -- it's removed. The bubble is separated from it.

CHAIRMAN WALLIS: Yes, right.

MEMBER ROSEN: But it hits the surface, the bubble separates, and it falls down again. This goes on as long as the chemical reactions go on. You can do it in your kitchen and --

DR. LETELLIER: Two comments. Number one, I'm not sure that the Reg. Guide focuses exclusively on precipitation. I think the words are accurate here that it requires consideration of debris generated by chemical reactions.

CHAIRMAN WALLIS: But it also talks about -- demonstrates that suspended indefinitely or to sink very slowly should be considered to reach the sump screen. It seems to me that stuff which is liable to have bubbles on it and to go through this dance could be considered to be suspended indefinitely.

MEMBER KRESS: I can't believe you're going to produce enough gas in this temperature and condition that it's going to be a significant issue.

CHAIRMAN WALLIS: Show us the --

DR. LETELLIER: That's my second comment is I'm not sure that the scenario that you portrayed is actually realistic.

MEMBER KRESS: Yes. You --

DR. LETELLIER: Keep in mind that the gas generation occurs on exposed metal surfaces. There are not a lot of exposed --

CHAIRMAN WALLIS: Flakes of aluminum paint.

MEMBER KRESS: Yes. But they don't react -- they're in the water, and this is -- this water temperature is --

CHAIRMAN WALLIS: It says it's got NaOH in it, and all kinds of stuff. It's high pH according to the Los Alamos.

MEMBER KRESS: It's supposed to be high pH to control the iodine problem.

CHAIRMAN WALLIS: That's right.

DR. LETELLIER: The inorganic zinc might be a credible debris source where that should be examined.

CHAIRMAN WALLIS: Well, I don't know. I just assumed that if it's -- if it is a contributor to the hydrogen source term, there must be quite a bit of gas, because there are other contributors. I mean, it's not negligible. It doesn't take much gas to float a particle. Gas has no density at all relative to the water. So, anyway, this should be there somewhere it seems to me.

DR. LETELLIER: I think the focus of hydrogen generation has been on hydrogen deflagration within containment where your exposed metallic surfaces are impinged by sprays, and the bulk of those metals are not submerged in the pool.

CHAIRMAN WALLIS: Well, they're zinc aluminum paints, right?

DR. LETELLIER: That's true.

CHAIRMAN WALLIS: So they are part of the debris. So I would really appreciate -- and there's aluminum foil in -- crumpled up in this insulation which gets transported, and all that, and it's not something you can just dismiss.

The other thing that there was a comment about that I didn't see on to very well was this business of transient debris. It has been raised by this committee, too, that plastic sheeting, duct tape, and stuff, which happens to be there for maintenance purposes or something, or someone left it there, is simply dismissed as being not something you consider because of risk. Somehow it's considered in the risk analysis. It's not considered as relevant to the screen blockage problem. Why is that?

DR. LETELLIER: No. In fact, it has been considered and excluded based on transportability. Under circulation --

CHAIRMAN WALLIS: That's not the argument used by the staff in dismissing it, in dismissing the public comment. Maybe there's a physical reason for dismissing it. But they say it's all taken care of by risk, so -- which seems to me very strange.

I have to find it now. Anyway, we can find it. The transient debris public comment.

MR. CARUSO: I'm confused. You said that the sheet material is not transportable?

DR. LETELLIER: Not during recirculation, flows typical of recirculation phase.

MR. CARUSO: On page 2-1 of the knowledge base, it says, "Transportable sheet-like materials, numerous miscellaneous, relatively transportable materials were found that could essentially behave like a solid sheet of material when they're on a strainer screen." Plastic cloth, duct tape, oil cloth, all this -- I don't understand. Are you saying that this is not transportable?

DR. LETELLIER: I hate to mince words. But if you read the recommendation, it says if they are present on the screen, they are of concern.

MR. CARUSO: Why are they listed under "transportable," then? There's another category which is relatively non-transportable.

DR. LETELLIER: There are debris types

that should be considered. And based on your assessment of the fill-up phase, it would be possible to transport that material to the sump, if, for example, the sump represented a very large recessed volume compared to any other location in the facility.

Then, the flows would be preferentially directed towards the screen at a high enough velocity to transport those materials.

MR. CARUSO: This is a pretty simple question, though. You said that they are not transportable, but you've got a document here which says -- which has two categories -- transportable sheet-like materials and relatively non-transportable materials. And non-transportable is hammers, bolts, nuts, stuff that I would expect is non-transportable.

But then you have a category that's called specifically transportable, and it includes all the stuff that Dr. Wallis is concerned about. Is it transportable, or is it not transportable?

DR. LETELLIER: It depends on the velocity regime that you're considering.

CHAIRMAN WALLIS: Well, I guess I'm not concerned about it. It's NEI that's concerned about it, because their public comment says the guidance does not address transient debris sources. Personnel perform work within containment, so on and so on.

And then, the resolution is dismissal of transient debris sources would be based on risk aspects which have not been otherwise included in the Guide. So they are being dismissed on the basis of risk.

DR. LETELLIER: Well, again, I think we should look at the word --

CHAIRMAN WALLIS: Physically.

DR. LETELLIER: What you read means that if you choose to dismiss these debris, you must have a risk argument to go along with it. I don't think that it implies that those debris have been dismissed with the --

CHAIRMAN WALLIS: Well, does it say that? Does the Guide say that? It just says "disagree." The Guide doesn't seem to address the question at all of transient debris sources.

DR. LETELLIER: Which question number is that, by the way?

CHAIRMAN WALLIS: It's NEI comment number 3.

DR. CHANG: I believe in the record we address those things should be considered as to debris -- let me find it.

CHAIRMAN WALLIS: Well, it's something that we're going to need to look at and resolve. I don't think we can spend the time on it now.

DR. CHANG: I'll try to find it later.

CHAIRMAN WALLIS: I really would appreciate it, some analysis of the hydrogen generation. Even if it's a very small amount, as my colleague says here, then it has to be a very small amount. It's not going to be able to lift up some of these fragments of zinc and aluminum paint.

DR. CHANG: On this chemical reaction issue, the comment is that there is no -- there seems to be no publication out there that NRC published reports of study or cited available references. Our answer is that we acknowledge there are no NRC published references pertinent to this issue that can be cited in the Reg. Guide.

CHAIRMAN WALLIS: So what I'm looking for is a more thorough statement of, what are these chemical reactions in the pool? Other than just debris-generated, what is their effect on the debris? Not just new debris generated by them.

If we have time, Bruce has some slides on the chemical testing, the initial results we have obtained. So we can go them in a little bit.

CHAIRMAN WALLIS: If we have time at the end. I think we're going to run over time anyway, but we -- we probably -- we kind of thought we might anyway. It's an important issue, and we don't have enough time. But we don't have to have a very long discussion at the end probably, so I expect we can adjourn before lunch.

MR. CARUSO: Before you go to the next comment, can I ask a -- this is a naive question about zone of influence. It looks like you only consider double-ended breaks. You don't consider split breaks. Has anyone looked at split breaks at all, zone of influence for split breaks?

DR. LETELLIER: There are correlations available based on the length or the extent of the pressure contour normalized by the orifice diameter. And that would be an appropriate set of data and information to use if you chose to postulate a conical break, like from a fish-mouth orifice.

And, in fact, the NEI is faced with making that choice when they propose a postulated break size based on fracture mechanics. In fact, they have a one-sided jet, and not opposing conical jets that lead to a sphere.

MR. CARUSO: So they just idealize the

fish-mouth, the split break, into a hole of a certain size.

DR. LETELLIER: Yes. Now, keep in mind that the generalization of a --

MR. CARUSO: You can do a round hole of a particular size.

DR. LETELLIER: That's what I mean.

MR. CARUSO: And they don't take into account the geometric effect of a long break as opposed to a round break.

DR. LETELLIER: I believe that's correct. Keep in mind they're trying to establish a compromise between the leak before break, which is essentially a zero damage zone, no appreciable pressure release all the way up to the double-ended guillotine. And so they're looking for a middle ground.

Now, one other point of clarification, the spherical zone is an assumption for convenience, because we don't have predictive models for jet deflections and recollections.

MR. CARUSO: I was just curious.

DR. CHANG: And also, in the workshop in July, I heard that if they consider using the fracture mechanics and considered like it's a hole on the pipe and stuff like double-ended guillotine break, then they use the hemispherical zone -- use a hemispherical zone.

MR. CARUSO: Okay.

MEMBER KRESS: You're taking the jet cone and finding the pressure that would cause damage to a particular kind of debris out to a certain distance, and that has a volume. And then, my understanding is you're going to make the same volume in a sphere around the pie?

DR. LETELLIER: That's correct.

MEMBER KRESS: That really seems strange to me. I think -- I could go from no -- lots of debris to no debris with that, because you're shrinking the distance of an influence when you do that.

And it seems to me like a more conservative approach would take that distance of the jet influence and draw a sphere at the end of that around the thing, which is a much bigger volume. And that really strikes me as a hokey thing, and it's --

CHAIRMAN WALLIS: But it's the basis of the whole model of generation of debris.

MEMBER KRESS: Yes. And I'm really surprised that we got this one through.

DR. LETELLIER: Keep in mind that the

spherical approximation for a large break LOCA generates a sphere that's over -- between 30 and 40 percent of the containment volume. So even under our current --

(Laughter.)

MEMBER KRESS: That's a lot.

DR. LETELLIER: It is. So if you did what you propose and take the maximum radius --

MEMBER ROSEN: It would be everything.

DR. LETELLIER: -- you would always --

MEMBER KRESS: Yes. Well, I could see that would be an issue.

MR. CARUSO: I mean, I have a very clever garden hose that allows me to dial in different destruction jets. Okay?

(Laughter.)

And I can get very different destructive events, depending on how -- what setting I've got it. Either, you know, a good, solid stream -- it even has this wide flat setting that you can use. And if you're an insect, it matters, you know, whether --

(Laughter.)

-- I have it aimed very carefully, or whether I've got it set on wide destruction.

MR. HSIA: That's why our resident

inspector makes sure they don't have a garden hose like yours in the containment.

(Laughter.)

CHAIRMAN WALLIS: No. But the pipe may have a slit or a hole or -- just like his garden hose.

MR. CARUSO: That's why I asked the question. But we don't consider that. We just consider one round hole, and we vary the size.

CHAIRMAN WALLIS: Ralph?

MR. ARCHITZEL: I just want to make one comment on chemical before you move on. I did want to raise an issue -- it was raised at the workshop -- and that is basically that there's a certain amount of -- if you do get a chance to hear it, you may want to listen to it. But the industry was concerned about not moving forward until there's more knowledge in this area, because they don't know how to address the issue.

So there is a question about timing and resolution of the whole issue associated with chemical precipitation. So you may not need to get into it today, but I'm just pointing out that the industry is concerned and we had indications that until there's more known there's nothing being done to fix this problem.

CHAIRMAN WALLIS: And it's not just precipitation. It's --

MEMBER ROSEN: Well, the implication is if we can find something that we don't know something about, we can delay doing anything forever.

MEMBER FORD: Do we know if industry is moving forward? You say that industry isn't moving forward, or they want --

MR. ARCHITZEL: Well, we have a meeting coming up; we're going to talk to them about it. But the fact is that even our Office of Research isn't taking what's been done any further, so that you can't take what's been done and translate that at the moment into how you do, you know, these complicated analyses, how you factor the precipitation in.

MEMBER ROSEN: Let me just be a little more clear, Ralph. This one ACRS member is not comfortable with the idea that all we need to do is find someone who can ask a question that no one knows an answer to about this, and then we won't have to do anything until that question is answered. I'm simply not -- that is not an acceptable way to work on this problem.

MEMBER FORD: I didn't quite hear your answer to my question, which relates to what Steve is saying. Is EPRI being proactive on this, and trying to fill in some of the gaps that -- the quantity of gaps in our knowledge?

MR. ARCHITZEL: This is a new issue. I think we've got a meeting scheduled with NEI in September, early September, to try and see --

MEMBER FORD: Well, this is --

MR. ARCHITZEL: -- will they do some research, if we don't, because you need to tie the end of this together. They may be. I think they will be. I'm not sure they're not.

MEMBER FORD: Do they not feel as though it's a high priority item? This has been going on a long time now. They don't see that as a high priority item?

MR. ARCHITZEL: This particular issue -- chemical precipitation -- is a new twist, something that people didn't know about.

MEMBER FORD: Okay.

MR. ARCHITZEL: So they're just being presented with this now as well. It wasn't out there before.

CHAIRMAN WALLIS: Please present them with the whole question of all the effects of chemical reaction, not just precipitation.

MR. HSIA: Tony Hsia from Research. We have been undertaking research on chemical reaction and effective chemical reaction on debris. T.Y. was --

CHAIRMAN WALLIS: Well, let me ask you -- when you have this borated cooler, and you pour in the sodium hydroxide --

DR. LETELLIER: Sodium hydroxide is present in --

CHAIRMAN WALLIS: -- it makes sodium borate, or something like that? What do you make? You must make something like sodium borate? What is that?

DR. LETELLIER: Sodium hydroxide is present in the reactor coolant as a pH buffer, essentially.

CHAIRMAN WALLIS: Well, I'm surprised that you're going to go to a high pH in the pool. It's just because of the iodins, or additional NaOH must be poured in presumably.

MEMBER ROSEN: There is during --

CHAIRMAN WALLIS: To get the high pH -- in other words, you have a low pH from the boron.

DR. LETELLIER: Yes.

MEMBER ROSEN: There's also lithium.

DR. LETELLIER: That's right. And the lithium is --

CHAIRMAN WALLIS: And all of these things interact in some way in the pool and make things which do things, make it slimy or gooey or something. All of this affects the quality of the precipitate of the stuff which is going to get on the screen.

DR. LETELLIER: That's correct. And we are looking at that, and we would be happy to share some of --

MR. HSIA: If you could indulge us to go through the presentation, at the end Bruce had some updated information he would like to share with you.

CHAIRMAN WALLIS: Okay.

MR. HSIA: And I fully agree with Dr. Rosen. I think at this stage we need to move forward with the best knowledge we can, instead of sitting until we solve every single issue, although they important. That's not the right approach from --

CHAIRMAN WALLIS: Well, you can resolve it by being very conservative, I think.

MR. HSIA: Correct.

CHAIRMAN WALLIS: But that might have some real implications for many plants.

MR. HSIA: Correct. Correct.

MEMBER ROSEN: We already have real implications for many plants. We have a question on whether or not we are going to succeed in long-term cooling. That's a significant issue.

CHAIRMAN WALLIS: Which is the last comment. Maybe we can move on to the ACRS comment period.

DR. CHANG: Yes. ACRS, in their letter after the last February meeting, ACRS asked a question that -- because of the susceptibility of sump to debris blockage, other alternative solutions should be looked into to ensure long-term cooling. And the staff was asked to invite the public comments on this issue, and we didn't get any comment from the public on this.

MEMBER ROSEN: The silence was astounding.

CHAIRMAN WALLIS: And actually, it's C.1.2. It's not C.1.1.4. It's C.1.2 -- in my copy of the Guide anyway.

DR. CHANG: C.1.1.4 is about the active sump screen system. So we added that to indicate --

CHAIRMAN WALLIS: This isn't in response to our comments. C.1.2 is in response to --

DR. CHANG: C.1.1.2 --

CHAIRMAN WALLIS: This was supposed to be a serious comment, and we think this is a problem. It just may not be resolved by analysis of debris transport and all that stuff. It may require that you ensure long-term cooling if the strainers are blocked.

DR. CHANG: Yes. But, again, Bruce has some ideas he wants to share with us --

CHAIRMAN WALLIS: We felt this is a very serious --

DR. CHANG: -- about this issue. He has some slides. Actually, I think you had a handout. You had -- you have two handouts. The other one is on these alternative solutions.

DR. LETELLIER: At this point, there is no substantial information on alternative solutions that we could actually put into the Reg. Guide as beneficial guidance.

DR. CHANG: Just some ideas I guess.

MEMBER ROSEN: Didn't we see one sitting on the floor there at the workshop? I mean, a self-cleaning strainer.

DR. LETELLIER: Yes.

MEMBER ROSEN: I don't understand your point that there are no alternative solutions when one was being offered by a vendor.

CHAIRMAN WALLIS: Wasn't that the point of that -- I mean, the ACRS comment was that you might have to get water from somewhere else. Wasn't that really our point?

MEMBER ROSEN: Well, yes. But we're flexible enough to realize that maybe even we couldn't perceive an alternative solution that somebody else could. Even us. Even us.

MR. HSIA: But with the leadership provided by ACRS members, we would like to say that our position is we, like Bruce will do later on, we will present some alternative suggestions. But it's really up to the licensee is what -- you know, they have dollars involved. We can be sitting here coming up with very creative fixes, but from an economic point of view they need to cover safety as well as their checkbooks.

DR. CHANG: Regarding the alternative water sources, this is in the Reg. Guide. They can consider alternative water sources as another alternative, if they have the procedure and the training of the operator, and so forth.

CHAIRMAN WALLIS: I think we might move on to the next topic. And I suggest since we're over time -- but I think we're asking questions we would otherwise have asked later in the day, so we may catch up. T.Y. has part of this next presentation.

DR. CHANG: Right. It's going to be a tag-team approach.

CHAIRMAN WALLIS: If you give your part, and then we have a break before we hear from --

DR. CHANG: It's an alternative. I'll give my part, and then Bruce will chip in. So that's the setup.

CHAIRMAN WALLIS: I don't think we have time to go through the whole thing before the break. But if you can give your part of it --

DR. CHANG: The first --

CHAIRMAN WALLIS: -- then break at a time before Bruce comes in and talks about all the technical matters, then perhaps we can get in the break.

DR. LETELLIER: We intend to address these topics. There are about five separate issues.

CHAIRMAN WALLIS: But it will take quite a long time, won't it?

DR. LETELLIER: It will. We could do the first one, as a suggestion.

DR. CHANG: So maybe we -- let's take the break now and --

CHAIRMAN WALLIS: Take the break now? If

that's what you'd like to do. It's a good break point.

MEMBER ROSEN: It's only five minutes before we're scheduled anyhow, so --

CHAIRMAN WALLIS: Okay. And then we'll try to catch up. But I think we may have to go after 12:00 noon. Just delay lunch. So you've got an incentive to speed up.

Okay. So we'll take a break until 10:25.

(Whereupon, the proceedings in the foregoing matter went off the record at 10:10 a.m. and went back on the record at 10:29 a.m.)

CHAIRMAN WALLIS: We are on the next section.

DR. CHANG: Shall I proceed?

CHAIRMAN WALLIS: Yes, please.

DR. CHANG: The next topic is a summary of our positions in the Reg. Guide, positions and acceptable methods, and also a discussion from Bruce about how those things can be applied in a real plant.

We look at the excellent sequences and it consists of the following: debris sources of generation, then after that you have the debris transport. That includes three types of debris transport -- the airborne, right after the blowdown, the pipe radiant blowdown, debris is generated, and it can be blown to the containment, and so forth. So this is the airborne debris transport phase.

Then, after the containment spray is turned on, you have washdown debris transport phase. And the sump pool debris transport is on the floor of the containment. You have the flow of all the liquid there, and we have to look at the debris transport in that area, too.

Then, we have a special slide on the sump pool debris transport, and then, lastly, is the collection of all the debris on the screen and what is the head loss because of that.

Next slide, please.

Under the debris sources and generation, consistent with the requirements of 10 CFR 50.46, we have the same words, actually. It says that a number of LOCAs of different sizes and locations should be postulated to provide assurance that the most severe postulated LOCAs are calculated. We've added a few words there for the regeneration calculations.

The original words in 50.46 is for the ECCS cooling and performance calculation. So our thinking is that for consideration of debris generation you have to be as severe. You have to consider the most severe postulated LOCAs.

And the second bullet is that when we talk about severity, the level of severity should correspond to the postulated break based on potential head loss incurred across the sump pump.

So, actually, this is sort of like -- I think Bruce used the word "break to block." You have to consider the block effect to predict where you have to consider the break.

Then, zone of influence is one of the methods that can be used to estimate the amount of debris generation by a postulated LOCA.

MEMBER KRESS: Now, let me ask you about the first bullet. In Appendix K for ECCS LOCA, they look at the pipe size in postulated, double-ended break here. And the way they vary the pipe size is they look at different pipes that are in the thing, and then -- and break each one of them.

Now, the question that I have about that is, you have a combination, then, of location and pipe size, which determines the severity of the break, and then what is around that particular location.

What's to prevent a big pipe in a given location from having smaller breaks? And is there --

if a pipe is a certain size, is the double-ended guillotine break the most severe for that pipe? So you don't have to worry about smaller breaks in that pipe.

You could do the same thing with -- that they do in Appendix K and just look at different pipes that exist in different locations?

DR. LETELLIER: That's the common practice, to assume that double-ended guillotine break represents the maximum orifice that can be created in a given pipe, and implicitly assume that that is the maximum damage that could be created also.

You don't need to consider small breaks in large pipes unless you need to do a risk analysis where that may dominate the proportion of events.

MEMBER KRESS: Okay.

DR. CHANG: And also, we don't limit ourselves to LOCAs only. If a plant -- the recirculation is needed for a high energy line break, such as main steam or feedwater, then those high energy line breaks should be considered as well. And the most limiting conditions for sump operation should be considered.

And, lastly, all potential debris sources should be considered within a particular ZOI.

CHAIRMAN WALLIS: That excludes any sources anywhere else, such as this floatable plastic sheet.

MEMBER ROSEN: Well, that's for the zone of influence from the break. But the floatable plastic sheet could be someplace else and floated down by washdown, by one of the other mechanisms.

CHAIRMAN WALLIS: Is that considered?

DR. CHANG: Yes. And when you have latent debris and all that --

CHAIRMAN WALLIS: So all that as well. Okay.

DR. CHANG: Yes.

CHAIRMAN WALLIS: I'm sorry. Because I thought it just meant it should be considered only within the ZOI.

MEMBER ROSEN: No, no, no.

CHAIRMAN WALLIS: Oh, okay.

DR. LETELLIER: These are some of the highlights out of the Reg. Guide. We couldn't address every portion.

DR. CHANG: And the next slide, please.

Continuation of debris source and sources and generation. In the Reg. Guide was the position that as a minimum those break locations should be considered. Perhaps the coolant system -- or main steam and main feedwater, if needed -- with the largest amount of potential debris within the postulated ZOI.

And the next one is large breaks with two or more different types of debris within the expected ZOI. Breaks in the areas with the most direct path to the sump. I think that's obvious.

And then, the last two -- I think they are interrelated. It's about the thin bed effect. So the break with the largest potential particulate to the insulation ratio by weight should be considered.

DR. LETELLIER: Now, the next slide tries to address or introduce you to the acceptable methods. Now, we talked about a number of these back in the February subcommittee meeting where I went through a rather exhaustive survey of each phase of the accident sequence. But I felt that it was necessary to -- or useful to reemphasize some points that T.Y. has made.

In order to assess so many different suggested break locations, some sort of spatial model or drawings, information about your plant, is essential. And, in fact, at the workshop we saw where the plants are making progress at reconstructing that information where it did not exist before. Some plants already have three-dimensional CAD inventories of their insulation and piping systems.

The methodology that they choose for assessing the various locations is entirely up to them. There is always the conservative approach of 100 percent damage, if that's a tenable solution. Otherwise, some sort of mechanized, systematic survey may be necessary.

Essentially, we're interested in postulated breaks in all systems that lead to a recirculation requirement. That is the scope of GSI-191, long-term cooling. And so main steam line breaks, for example, or steam tube ruptures can lead to a requirement for recirculation in some plants.

The third bullet -- having a definition of break severity that's defined in terms of a potential head loss, that implies a break to blockage transport analysis, even if it's done only crudely with transport fractions -- 50 percent, 70 percent.

You have to be able to assess the impact of a postulated break on the eventual head loss. That's the reason, for example, that pipe size alone, as defined for the purpose of cooling capacity, is not the single criteria.

CHAIRMAN WALLIS: So that means that if

you have, say, a big pipe, you consider different places where it might break, and you consider if it broke here, there's more debris in that area, although it's got a zone of influence that's humongous no matter where it is. But it would be worse to have it here from the point of view of dislodging stuff.

DR. LETELLIER: For small breaks, that's more likely to happen, because the zone of influence is smaller. And in some plants, we've noticed that there is more small piping in the vicinity of problem debris, for example. That's the rationale that we use to add the words for maximum number of debris types, for example.

As far as acceptable methods go, we've mentioned the 100 percent criterion, and that's always an option that we won't dwell on. However, there is a precedent in both NUREG-6224, which was the cornerstone document for the BWR resolution.

It sets a precedent for a point-by-point break analysis, where we proceed systematically through all of the piping systems and examine many hundreds of potential breaks. That is a method that's familiar to the staff and would be deemed acceptable.

Now, that's not to say that this is a requirement for every plant. The spatial details may be simplified, for example, by considering the plant-specific insulation applications -- predominantly, RMI plants, reflective metallic, may not have to do as exhaustive a search for break locations. They may focus primarily on the areas that include the fibrous material, some residual material. And there's a wide variety of plant configurations.

The next slide, 23, points you to some specific references to address the panel's interest in peer review. I think you've got the impression that we have shared our research findings with industry in a participatory fashion for many, many years, both at the local and international levels.

It's very difficult to point to examples where a formal peer panel was convened in a formal process. But there have been a number of important opportunities for critique and criticism, and they're listed here.

For debris source references, there was an early survey of insulation types used done in 1981. More recently, in response to Generic Letter 97-04, the NEI conducted a plant-wide survey that compiled a list of industry responses to specific questions asked by the staff.

And the knowledge base reference will come up repeatedly as a blanket document. It's the most recent compilation of research findings that has been subject to international critique. And, again, we could look at the comment resolution history and make a judgment whether that was adequate in the committee's opinion. But, in fact, it was open to everyone's input.

CHAIRMAN WALLIS: It seems to me that the regulatory process cannot be independent of the knowledge base. If the knowledge base is very precise, you have a certain kind of regulatory process. If the knowledge base is extraordinarily vague, then you're going to have a different appropriate regulatory process.

I think one of the things that concerned me was that the -- there seemed to be -- these didn't seem to be the right -- didn't seem to have the right connection. The Guide is asking for all kinds of calculations. The knowledge base doesn't let you do it.

If the Guide was more acknowledging that you couldn't do things, and said that you should assume other things, then they might fit together better. I think that's a concern I have.

DR. CHANG: The attempt here is trying to establish the link as far as we can in this presentation.

MEMBER FORD: But following up on Graham's comment -- this is really a tag-team act here -- this is an excellent source for the utility to go away and find out, well, what sort of debris sources should they be worried about?

But practically, surely the debris source that they should be worried about for their specific plant will depend on details of the break, type of -- whether it's spherical or what sort of break it is, if it depends on the various transport mechanisms for the specific debris.

So you just can't take this by itself. Is that a true statement? And so this knowledge is not enough --

DR. LETELLIER: Debris source is --

MEMBER FORD: -- to satisfy some of the requirements in your Regulatory Guide.

DR. LETELLIER: That is correct. And that's why I emphasized the philosophy of a break to blockage analysis. You have to integrate all steps, all phases of the accident sequence before you can decide whether you've found the most conservative or the bounding event.

MEMBER FORD: But I don't see the -- in your report here, knowledge base report, you talk about quite specific -- this, then this, and then this. They're not tied together. Is that true? Is that a true --

DR. LETELLIER: That's a fair observation. Now, the document that will come up here shortly, NUREG-6224 represented an integrated analysis of a BWR vulnerability assessment. That's the best template that we have for the end-to-end consideration of effects.

There has been an ongoing project in the NRC to conduct a volunteer plan assessment that would have provided a very similar example of how to apply the integrated assessment. Various priorities have pushed that aside for the moment. But I'd have to say that even the volunteer plan assessment relied very heavily on 6224, and that is available.

MEMBER FORD: Now, why aren't the utilities doing all of this work?

DR. LETELLIER: Ultimately, they will. Ultimately, each utility will have to conduct a similar assessment.

MEMBER FORD: I'm talking about the utilities as an industry, as a conglomerate. This is a generic problem. So why aren't the utilities --

DR. CHANG: Well, they are trying to come up with utility guidelines through the NEI. So there's a general document that -- I think they are talking about at the end of September, will they have that document ready for us to review.

MEMBER FORD: And the information is there, so they can come up with an integral -- integrated approach to this?

DR. CHANG: Hopefully.

DR. LETELLIER: Their guidance will be based heavily on the knowledge base and what's available in the literature. I guess maybe a personal concern is that the knowledge base is not comprehensive. It does not address all of the materials of potential concern.

MR. ARCHITZEL: We'd like to point out that even though we're going to get that schedule now in September, we have had ground rule documents over the last four or five months on some of the areas. So they have been doing something. They've given us some high-level type information as to how they plan to address this. So it's not like they're just starting this month. They --

MEMBER FORD: Okay.

MR. ARCHITZEL: They have been looking into it.

DR. LETELLIER: So let's go on to the associated consideration. The zone of influence -- and we've already talked a bit about this. Maybe I should simply ask for questions to clarify our assumptions of the spherical zone of influence.

Keep in mind that it is dependent -- the correlations are dependent on the break size, and the damage pressure of the debris type you're interested in.

CHAIRMAN WALLIS: Well, let's see. This is a model. Have there been tests that show that using a spherical zone of influence with the sorts of piping you might get and the sorts of pressures you might get and the scales you might get actually work reasonably well?

DR. LETELLIER: There have been some tests with double-ended guillotine, with no offset, with complete separation but no offset, that show that opposing cones tend to deflect in a roughly spherical manner.

And the argument perhaps more appropriate for the BWRs is there is so much piping congestion that the random deflections will lead to a zone roughly like a sphere. It's an assumption made for convenience. It does not account for the loss of energy during redirection of the jet. It essentially maps the pressure contour from a free jet expansion into an equivalent volume sphere.

CHAIRMAN WALLIS: Why isn't the pressure everywhere -- stagnation pressure, bring it to rest?

DR. LETELLIER: These are the stagnation pressures that would occur against a blockage.

CHAIRMAN WALLIS: So it must -- there must be some dissipation or something of energy out there. If you typically take a flow coming out of a pipe isentropically, and then bring it back to rest again, it goes back to the pressure it started at. So something must happen to disperse it.

DR. LETELLIER: I'm not sure that I understand the question. You're talking about free field expansion and --

CHAIRMAN WALLIS: Well, if I take my colleague's garden hose with a pressure of 40 psi, or 50 psi, let's say, g, and I direct it at a wall, I get 50 psig on the wall, unless there's some kind of losses in the flow.

DR. LETELLIER: These are freely expanding gases that are expanding into a lower pressure.

CHAIRMAN WALLIS: Yes. But then, when you compress them again, they go back to where they started from, unless there's some dissipative mechanisms.

DR. LETELLIER: Well, the dissipative mechanism is partly geometric as you expand.

CHAIRMAN WALLIS: Well, I don't think that works out, though.

MEMBER KRESS: I don't think you expand isometrically.

CHAIRMAN WALLIS: I said it's isentropic.

MEMBER KRESS: Yes, it's isentropic.

CHAIRMAN WALLIS: There must be some losses there.

DR. LETELLIER: Yes. You can't expand isentropically.

CHAIRMAN WALLIS: Why not?

MEMBER KRESS: Somewhere in between the two.

DR. LETELLIER: The damage pressures were actually based on test data where they had witness objects positioned at various points in the jet, so that the damage pressures could be correlated to some of the ANSI and ANS jet models at the -- under acceptable methods at the bottom of this slide, it lists some of the tools that are available.

For example, the industry is interested in redirecting the jet to -- I guess to alleviate the limitation that we're ignoring concrete barriers essentially. There is no jet deflection, no truncation due to walls.

But what they would like to attempt is to remap the equivalent pressure volume into the compartments where the break occurs. And to do that, they will need access to tools like the ANSI/ANS model.

MEMBER RANSOM: What kind of tool did you say?

DR. LETELLIER: There are models available for free jet expansion.

MEMBER RANSOM: Free supersonic?

DR. LETELLIER: Right. To look at the shockwave generation. Two of those are mentioned by -- reference ANS in the EPRI jet model.

MEMBER RANSOM: I guess one of my comments would be the -- you know, a free jet even is very non-uniform in terms of the -- it doesn't have spherical profiles in it. And it actually has shocks in it caused by the ambient pressure and compression on the boundary.

And I'm wondering if actually a better model for the damage is the dynamic pressure, one-half fluid density squared, which varies somewhat from the stagnation pressure. But generally, it's, you know, what dictates drag and --

CHAIRMAN WALLIS: Does he know what he's talking about?

MEMBER RANSOM: It's something close to the stagnation pressure --

CHAIRMAN WALLIS: I think he's talking about the -- that the pressure you measure is the -- bringing this stuff to rest on a wall or something.

MEMBER RANSOM: Well, it's just the stagnation pressure.

CHAIRMAN WALLIS: Well, it's --

MEMBER RANSOM: Minus whatever you get in a shockwave basis.

DR. LETELLIER: I believe I'd have to do some more homework to give a specific answer to your question about the form of the model. I did want to point out that the precedent for a spherical destruction model was introduced very early, before 1985, as part of the USI-A43 resolution, where they postulated zones from complete damage to partial damage to zero damage.

And as data have been added to the knowledge base, this has been refined into a correlation. Again, the correlations are based on pressurized air surrogates for steam. And there were limited tests done for GSI-191 looking at two-phase jet expansion.

Unfortunately, the test data that was obtained was not extensive in scope. It was performed for a lower operating pressure and a smaller volume. And so scaling arguments were invoked to compensate for those differences, in order to adjust the assumed damage pressure of each insulation type.

CHAIRMAN WALLIS: I'm trying to think about the difference. If you have an explosion, and you get something like an acoustic wave which goes out, and that attenuates with area --

DR. LETELLIER: Right.

CHAIRMAN WALLIS: -- because it's not the same stuff. I mean, it's a wave going through, and the gas which is out here isn't the same as the gas which was in here. But when you have a flow of stuff coming out of a pipe, it goes out like a hose and it hits something, and unless that flow of stuff loses some mechanical energy on its way, it's going to have the same energy it started with.

DR. LETELLIER: Certainly, there are mixing processes on the boundary of the wave that --

CHAIRMAN WALLIS: So I think the spherical thing may well have originated from an analysis of explosion.

DR. LETELLIER: The assumption of a spherical zone is a practicality, just based on the uncertainties of deflection in a congested piping environment.

CHAIRMAN WALLIS: But if I'm a policeman with a hose trying to control a crowd, I don't want a spherical zone of influence. So, you know, you -- it's obviously a big assumption which -- and your reply about the empirical evidence seemed to be that for a certain kind of a break you could make -- map pressures in some way. And it seemed that they were roughly in a spherical pattern around the hole.

But did it show that if you used these pressures for damage calculations, you got the right answer, too? The synthesis of the spherical model with the damage, showing that you've really got the right pressure and damage with your model, other than just the pressure itself.

DR. LETELLIER: I think there are many acknowledged deficiencies to the assumption. But keep in mind that the purpose is to estimate or to conservatively estimate the maximum --

CHAIRMAN WALLIS: Well, look at Barseback. Barseback had a relief valve or something that popped, sent out jets of steam. Was the damage in the direction in which the jet went, or was it in the sphere? There must be some evidence there. You saw a description in your book here about all of these events. Did anyone go in and say, "These events show that there really was a spherical behavior," or not?

DR. LETELLIER: That's a very good question.

CHAIRMAN WALLIS: Well, I mean, that's the kind of question I have about all of this. There's the description of things that happened, and then there's somebody's thought model of what might have been a good way to represent it. And what's the connection?

MR. HSIA: Chairman Wallis, Tony Hsia from Research. I believe that the -- one of the reasons we proposed the spherical model as an alternative is to take into consideration the conservatism, because if you say the directional -- jet has a certain direction, and hits an object, then the argument would be, well, how do you know it's going to disorientation? How do you know it's not going to start with the jet going to the 90 degrees from this? So there's no end as far as which direction you should point the jet at.

So in order to cover that, we felt the spherical model -- as long as you have a break at that location --

CHAIRMAN WALLIS: But we don't think it is conservative, because the sphere attenuates.

MR. HSIA: So does the directional jet.

CHAIRMAN WALLIS: Yes, but not so much in the direction in which it's going.

MR. HSIA: Well --

DR. LETELLIER: We have not accounted for the attenuation of an actual spherical release. What we've done is assumed the free jet expansion that does have a characteristic pressure gradient, with no deflection, and we've remapped the equivalent energy into a sphere.

CHAIRMAN WALLIS: But if my obnoxious grandson wants to spray his charming cousin with a water jet, he aims the jet at the person. He doesn't put out a spherical jet, which would be useless. It would just be a gentle little mist and sort of around -- it's different.

MEMBER RANSOM: Let me try something and see if I understand what they're doing. It may explain your problem with this, too, Professor Wallis.

I think that, you know, the highest mark numbers are found along the centerline of the jet in a free jet. And those are the areas of highest dynamic pressure. And, of course, as you pointed out, the stagnation pressure is going to be constant along that. So it's all equal to whatever it was in the pipe.

Now, they have to assume a damage model, and worse damage is going to occur along the centerline of that jet. So I think what they've done is they simply said, "Okay. We're just going to take a hemisphere or a sphere and assume everything in that area is going to be damaged all along the centerline of the jet."

CHAIRMAN WALLIS: It doesn't, because they attenuate the pressure. They don't --

MEMBER RANSOM: No, no, they don't.

DR. LETELLIER: No, we don't attenuate the pressure.

CHAIRMAN WALLIS: You don't keep the pressure all the way out to the --

MEMBER RANSOM: Well, they do not preserve continuity and assume the flows through the spherical areas, I don't --

CHAIRMAN WALLIS: Well, they do, because the zone of influence is bigger for certain things than others. So there's a bigger pressure closer to the hole than there is further away.

MEMBER RANSOM: There's a bigger pressure where?

CHAIRMAN WALLIS: Closer to the break. They have a sphere for radiative, reflective, metallic insulation. We need the picture. And then, they have a sphere for calcium silicate and a sphere for fiberglass. This is because the pressures are getting less as they go out from --

MEMBER RANSOM: Well, that would be true of the static pressure, but not the stagnation pressure.

CHAIRMAN WALLIS: Well, but that's I think the question we have with us.

MEMBER RANSOM: Then they've got something screwed up.

CHAIRMAN WALLIS: This is an acceptable method.

DR. LETELLIER: The final point I'd like to make -- your analogy about a directed jet being more effective. That depends very much on the uniformity of your target. If you're concerned about a point target at some distance away, the directed jet is more effective.

But the compromise, the practical compromise was made that debris targets in congested piping system, they exist all around you. And that it's an acceptable approximation to map a sphere to --

CHAIRMAN WALLIS: Well, is it? Because I have the 15,000 cubic feet of fiber measured in the air handling units. And normally they would be quite a long way away from this hole, I think.

DR. LETELLIER: And, again --

CHAIRMAN WALLIS: But if I had a directional jet aimed at an air handling unit, it would presumably dislodge 1,000 cubic feet of fiber.

DR. LETELLIER: I don't think that the data support that. Even stainless steel jacketed fiberglass insulation can be quite robust.

CHAIRMAN WALLIS: Not against the stagnation pressure of one of these jets -- 2,000 psi?

DR. LETELLIER: Yes.

CHAIRMAN WALLIS: Yes?

DR. LETELLIER: The damage pressure changes from unprotected fiberglass damage pressure of

10 psi. You can achieve 140 psi damage pressure.

CHAIRMAN WALLIS: Well, I'm talking about 2,000, if we conserve the stagnation pressure, in the extreme case of a directional jet.

MEMBER ROSEN: That's a strong jet. Get hit by a 2,000 psi something, there isn't much insulation that could stand up to that.

MEMBER SIEBER: Well, with the exception of main steam and feedwater piping, most of the high energy lines are in cubicles where there is a physical boundary surrounding wherever the leak may be. And in that cubicle will be things like reactor coolant pumps, steam generators, other valves, other pieces of piping, small bore lines.

And I would think that with all of these obstacles in that small space that the assumption that a single directed jet would -- just wouldn't fit physically.

CHAIRMAN WALLIS: Old Faithful is a break in the pipe. And it doesn't have a spherical pattern.

MEMBER SIEBER: It doesn't have a lid on it either.

CHAIRMAN WALLIS: No. But you know it --

DR. LETELLIER: And it doesn't extend indefinitely. There are dissipation processes that --

CHAIRMAN WALLIS: No. But it's a focused jet, and the attenuation of that jet is not anything like as rapid as it is if you work it out from Surrey.

DR. LETELLIER: But keep in mind, again, the damage pressures were based on free jet expansion of experimental configurations where you had pressurized air with a perforated nozzle, perforated plate. And so those experiments do incorporate realistic dissipation mechanisms, and we are not taking credit for --

CHAIRMAN WALLIS: Was this pressurized air?

DR. LETELLIER: It was indeed.

CHAIRMAN WALLIS: Because if it's water, then it should keep going the direction it started in.

DR. LETELLIER: That's correct, and that's the reason I pointed out the distinction between the two-phase blowdown test. The database is quite limited, but we do understand what some of the discrepancies are. And we've tried to compensate accordingly.

Next topic?

DR. CHANG: The next topic is about the debris transport. In the Reg. Guide, we stated that debris transport analyses should consider each type of insulation and debris size. And the three types of debris transport should be considered. They are airborne, washdown, and sump pool debris transport.

And one conservative approach that is acceptable to the staff is that instead of doing a detailed analysis of those transports, one can simply assume that all debris will be transported and collected at the sump screen.

However, if all screens -- if all drains leading to the sump could become blocked, or eventually can be held up -- and that could happen in conjunction with the debris on a screen -- then the consequences could be worse than 100 percent debris transport to the screen. And this scenario has to be assessed as well.

So assuming all the debris are transported to the screen may not be always the worst case.

CHAIRMAN WALLIS: This is where the plastic sheet may come in, and blocking a drain it -- if it were close to the drain already, it might not have to move very far.

MEMBER ROSEN: This is where you don't get any water in the sump at all.

DR. CHANG: Right.

MEMBER ROSEN: Right, right. You just get air into the pipe, right? Do you --

DR. CHANG: This is completely blocked. The water level is very low.

MEMBER ROSEN: And the valves still get a signal to open, and the pumps get a signal to start, and all you get is air.

DR. LETELLIER: That's correct.

MEMBER ROSEN: Yes. Yes. That's what's going to -- should be analyzed here, right? That air ingestion?

CHAIRMAN WALLIS: Well, it doesn't cool the reactor.

MEMBER ROSEN: No. It does worse than not cool the reactor. It completely binds up the whole safety system.

CHAIRMAN WALLIS: Well, I think you don't want to inject air into a hot reactor anyway.

DR. LETELLIER: If you have no water in the sump, but then you violated your NPSH margin, you have no --

MEMBER ROSEN: Right. But I'm saying, couldn't it be worse than that? I mean, now you've got -- the analysis I assume you're asking for here is if you get no water in the sump, what really happens? Including air ingestion into the suction of the ECCS pumps.

CHAIRMAN WALLIS: Maybe the worst might be the --

DR. CHANG: There's always some water in the sump. But the sump level may be not as we expected, because --

MEMBER ROSEN: There's always water in the sump? How is that?

DR. CHANG: Because of the break -- flowdown of break flow, and now also containment spray.

MEMBER ROSEN: Are you assuming here it's all 100 percent blocked?

DR. CHANG: No. The block is the drain -- drain blockage.

MEMBER ROSEN: Okay. So you're going to get water some other way.

DR. CHANG: Right.

MEMBER ROSEN: Not through the drains, just washed --

MR. ARCHITZEL: I don't think we asked for that to be analyzed, I'm pretty sure. Maybe you don't understand the bullet correctly. You analyze it to prevent it from happening. You don't -- we don't have a design basis accident with the sump inoperable, so you need enough NPSH, and you fix it if you don't have it.

But you don't sit there and analyze the condition where you don't have NPSH, where you have no water in the sump. That's not what we asked utilities to do.

CHAIRMAN WALLIS: You just decree it can't happen.

MR. ARCHITZEL: We asked them to make sure to analyze it, so it can't happen.

DR. LETELLIER: We're using NPSH margin as the threshold of concern. If you've lost margin, then we effectively assume that you have no capacity for long-term cooling.

MEMBER ROSEN: What does this statement in the last bullet on the slide that the consequence could be worse than 100 percent transport mean?

DR. LETELLIER: If, for example, that you had a screen design that was capable of accommodating 100 percent of the debris -- of the insulation inventory, with acceptable head loss across that bed, it would be far worse if you had an alternative condition that blocked all of the drainage paths and prevented water from reaching --

CHAIRMAN WALLIS: And you have a dry sump.

DR. LETELLIER: That's correct.

CHAIRMAN WALLIS: Right. And that's something that is of concern.

MEMBER ROSEN: That's right. And so you have the dry sump. Now I ask, what happens then? I mean, is that a legal question?

DR. LETELLIER: If you have no water, you have no margin. And so that's, in effect, a regulatory failure. We're not concerned about the consequences or the progression of that event.

MEMBER ROSEN: Okay. So it gets worse, but you don't -- you already lost the game 56 to nothing.

DR. LETELLIER: That's right.

MEMBER ROSEN: So why do you care if you lose it 65 to nothing?

DR. LETELLIER: That may be a legitimate concern for recovery of mitigation options, but not for the purpose of regulatory guidance.

MEMBER ROSEN: Okay.

MR. ARCHITZEL: That would be in severe accident spaces.

MEMBER ROSEN: It's a worse severe accident space consideration perhaps, but it's not a -- we're not talking about that yet.

MEMBER FORD: But is there any mechanism to toss that concern onto some other group? I mean, you're drawing a firewall down this particular situation. And you're saying, "Okay, I'm not considering that part." Well, who does consider that part? It's a communications issue, isn't it? I mean, who is --

CHAIRMAN WALLIS: NRR.

MEMBER FORD: What?

CHAIRMAN WALLIS: NRR.

MEMBER FORD: Well, yes. But I'm hearing, "No, we're not going to consider that."

MR. ARCHITZEL: I think design basis space in the Reg. Guide. But as far as severe accident goes, we have another branch that looks at -- they include failure of sump for different reasons.

MEMBER FORD: That would already be covered. That's already covered.

MR. ARCHITZEL: That's assessed outside of design basis accident. We're using this Reg. Guide for DBA analysis. We're not using the Reg. Guide for severe accident analyses. That's another group that looks at -- sump failure is one of the things that happens. How do you mitigate? It's probabilistic, it's a Level 3, it's not our group at all that looks at that.

MEMBER SIEBER: Well, this Reg. Guide is designed to provide an acceptable methodology to show that you comply with the GDCs, which specify that you ought to have recirculation capability. And so the other side of the question is, you know, if you don't comply, of course, you don't comply. And there's a problem; you ought to be shutting down.

But if you don't comply in the course of an accident, you're into -- beyond the design basis space and emergency planning and all kinds of things like that -- severe accident.

MEMBER ROSEN: So I guess the answer to your question, Peter, is that somebody else will look at the implications of this in severe accident space and consider one of these SAMAs they call them -- severe accident mitigation alternatives. And that the SAMGs, the severe accident mitigation guidelines, will somehow take note of this at some point and be revised. Is that what I'm hearing?

MR. ARCHITZEL: I'm not sure there's anything active in that area. I'm just saying it currently is an area that's examined by severe accident management guidelines and evaluated. Sump failure is one of those.

For example, when Davis-Besse came up and it was evaluated, you know, the -- what about it -- if the sump had blocked because of this hole in the head, you know? And then, it was evaluated by the PRA staff about, you know, you flood up around a vessel. And, yes, you don't have any recirculation, but you can have cooling that way. It is a potential to get onto --

CHAIRMAN WALLIS: My question was purely prompted by essentially a question of procedure.

MR. ARCHITZEL: Yes. I don't think there's anything active.

CHAIRMAN WALLIS: But someone is looking at it.

MR. ARCHITZEL: I don't think there's an active look at this.

MEMBER ROSEN: Well, you heard it here. Right, Ralph? Tony? You heard it here that someone thought, well, if it's as bad as that, what can -- innocent question, what happens then? And you need to think -- and your answer is, "Well, it's considered in severe accident space." And we tell you, "Okay. Pass that along to the severe accident people."

MR. ARCHITZEL: Right.

MEMBER ROSEN: Let them do so.

MR. ARCHITZEL: Right.

MEMBER SIEBER: Yes. But this is not a new issue. That was done 20 years ago -- severe accident --

MEMBER ROSEN: That may be the answer that the severe accident people tell us. It's not any worse than something we've already considered, so it's fine. That's okay. I don't want to make a big deal of it. I just want to understand the process.

DR. CHANG: To clarify one thing, I think, Dr. Rosen, when you talk about sump, I think there's a confusion of terminology. We use the sump pool as the floor of the containment. I was referring to the sump pool there as there will always be -- there is always going to be some water, whereas the sump you are referring to is the pit. Okay. So the dry pit is a possibility.

MEMBER ROSEN: Yes, I'm worried about a dry pit where the suction -- the end of the suction piping is.

CHAIRMAN WALLIS: Okay. Can we move on now, then?

DR. CHANG: Okay. Bruce, it's your slide.

DR. LETELLIER: To discuss briefly what methods are available to assess the transport during blowdown and washdown, the only method -- systematic method for doing this at the moment is to combine some information about updraft velocities and water drainage pathways with information about transport characteristics of debris types.

And the method that's been applied for the BWRs is this logic chart. It's essentially an event sequence that maps the disposition of various debris fractures -- the large pieces, the small pieces of each insulation type throughout containment.

We've actually used the code MELCOR to get some impression of the updraft velocity through the various compartments, what portions of the flow expand throughout containment, in order to make some informed judgments about what fraction of debris are transported.

CHAIRMAN WALLIS: This is slide 27, then? Is that -- you need to move this one.

DR. LETELLIER: My apologies. Thank you.

Ultimately, these judgments have to be made from the point of view of conservatism. If you are attempting to rationalize a washdown fraction of five percent, then you need to have supporting evidence to do that.

We've done a very detailed examination of our volunteer plant, and we find it difficult to argue for less than 60 percent transport back to the pool. Keep in mind that there is some initial impingement on the floor. Some portion of the debris will impact the floor and be available during pool fill-up.

The bulk of the fine debris will be lofted throughout containment, but it will be small enough to be entrained in condensation flows and spray -- through spray washdown.

So this logic diagram was vetted -- first vetted in 6224 as part of the BWR resolution. I should state that as a cornerstone document the 6224 was preceded by a PIRT review, so that they prioritized the appropriate phenomena.

The PIRT was reconvened at the end of that study. I'm sorry. I misquoted the reference. They were reconvened to examine the drywell debris transport study, which implemented this method. And so it has had a peer review in that context.

Again, a similar statement -- there are no integrated numerical models that are appropriate for transport of specific debris types. We have to combine flow velocity potential with transport characteristics.

CHAIRMAN WALLIS: You've said that it was difficult to argue for less than 60 percent of the debris being transported to the sump? Well, if that's a bottom possibility, maybe 80 percent is more realistic, and you might as well assume 100 percent to be conservative.

DR. LETELLIER: The purpose of our examination was largely to offer some recommendation whether that's cost effective to do, whether you choose to construct a phenomenology model to gain that advantage or not.

The next slide shows the references that are available. I've already mentioned volumes 1, 2, and 3 of the drywell debris transport study and the application of this method to the BWR resolution.

CHAIRMAN WALLIS: So now each plant is going to develop, based on this knowledge base, its own method? I think there's going to be huge diversity unless they fit up with an NEI guidance or something.

DR. LETELLIER: I expect that in large portion they will adopt the NEI guidance.

DR. CHANG: The next slide is about the sump pool debris transport. We stated that this transport should include debris transport during -- for fill-up phase and the recirculation phase, and also, the turbulence in the pool caused by flow of water, water entering the pool from the break flow, and containment spray vent drainage. Those are the water sources.

And thirdly, the buoyancy of the debris should be considered also.

CHAIRMAN WALLIS: Which includes mixtures of debris.

DR. CHANG: Right.

CHAIRMAN WALLIS: Including gas maybe.

DR. CHANG: For instance, if the debris is not broken down, if there is air trapped, it may be floating. But as the time goes on, if it disintegrates, then it would make -- eventually settle down to the bottom.

CHAIRMAN WALLIS: Yes, maybe.

DR. CHANG: Yes. So those things should all be considered.

Also, the debris that should be considered in the transport analyses are -- that float along the pool surface, that may remain suspended during the pool turbulence, and also those readily accessible to the pool force. So all sorts of debris should be considered in the transport analysis.

And I think we got this last bullet right.

We said CFD assimilation in combination with experimental debris transport data is an acceptable approach. So we are having to modify the Reg. Guide in this -- in those words.

And we also mentioned that alternative methods would be acceptable. I think this is a general statement true for the whole Reg. Guide, if they can be supported by adequate validation of analytical techniques using experimental data to ensure that the debris transport estimates are conservative with respect to the quantities and types of debris transported to the sump screen. Okay.

DR. LETELLIER: And the practical applications of this guidance are discussed next on slide number 30. When I made the statement before about 60 percent transport, that was specifically with regard to blowdown and washdown. So we're talking about 60 percent of the generated volume being introduced to the pool or at the floor level.

The additional fraction that's lost from pool transport is largely dependent on when and where it arrives in the pool. Debris that's impacted on the floor is subject to fill-up flow velocities, which can be very high, and they are very directional depending on the plant geometry.

That's probably the best opportunity for sequestering debris in quiet sump areas. For example, many containments have opposing steam generator compartments. If a break occurs on one side, the opposite compartment is very quiet and does not participate in directed flows.

Some portion of the debris will find its way into those areas. Elevator shafts and, in particular, reactor cavities also represent dead zones with significant potential for holding up debris. Before credit can be taken for those areas, some consideration has to be given to the drainage flow paths.

In our volunteer plant, we identified between 8 and 12 locations where you would be dropping between 500 and 1,000 gallons per minute in a fairly localized area. That's a significant source of energy of turbulence in the pool. And so there are phases with regard to the velocity pattern.

The picture that's shown is intended to represent the steady state flow velocities where the cylinder in the steam generator compartment is the source of the break, and the sump is near the bottom of the annulus. So this is sort of a steady state configuration that would persist for long term.

MEMBER ROSEN: The red is high velocity or low velocity?

DR. LETELLIER: The red is any velocity exceeding .2 feet per second. That's sort of a rule of thumb for transportability of various debris types.

MEMBER ROSEN: So anything in the red zone will transport. Anything in the blue/green zones will probably not transport.

DR. LETELLIER: That's correct. There is a potential for transport anywhere within the red zone. These patterns are very plant-specific. For example, our volunteer plant has elevated steam generator compartments, so there's essentially concrete inside of these cavities that cannot participate in the sump pool. They're excluded.

So, essentially, the annulus is the only volume where debris will reside. And that's a condition that's very vulnerable to additional debris degradation from --

CHAIRMAN WALLIS: So if it's in this region of greater than .2 feet a second, it's up in suspension, and it's flying along.

DR. LETELLIER: Or it's sliding on the floor.

CHAIRMAN WALLIS: And then, when it gets

to the blue region, it presumably doesn't instantly fall out. It sort of goes out and makes a pattern downstream, so you have --

DR. LETELLIER: There's an opportunity for a drift.

CHAIRMAN WALLIS: It's not clear there's nothing in the blue region. It's in the process of falling out there, but there may still be some in suspension.

DR. LETELLIER: That's certainly true, and we are more concerned at the moment about the suspended debris than the potential for sliding on the floor.

CHAIRMAN WALLIS: Where is the sump in this picture? Do you have that screen in this picture?

DR. LETELLIER: At the bottom of the annulus.

CHAIRMAN WALLIS: The very bottom of --

DR. LETELLIER: There's a bright spot.

DR. CHANG: It's sort of green in the center.

CHAIRMAN WALLIS: So it's enclosed by the red stuff.

DR. LETELLIER: Now, CFD models are one

methodology that the staff is familiar with for estimating the velocity counter. There are alternatives. The NEI is currently looking at open channel network flow models as an approximation to the bulk flow.

We are evaluating -- we will be evaluating that as an acceptable method. There is a potential for success. There is a wide range in the fidelity of the models. But in both cases, you have to make assumptions about how you're treating the variability in your input conditions. That's a common question that has to be addressed in both cases.

Again, the linear flume test characterized the incipient flow and settling velocities of our major debris types. And that database, in combination with velocity estimates, can be used to estimate transport fractions.

As far as the acceptable methods and what debris transport references are available, we've talked about using CFD versus network flow. Again, there are no integrated models specific for debris transport. Logic charts are the best systematic approach to assessing this fraction.

We do have peer reviewed articles on our CFD modeling of our scale tank tests that appear in nuclear technology. But, again, they are very specific interests. They are limited in scope.

And, finally, the list of references on slide 32.

CHAIRMAN WALLIS: It wasn't clear to me that the CFD modeling was systematically compared with data from the tasks. It seemed to be qualitatively predicting the right sort of thing, but I didn't see a measure of how well it did quantitatively.

DR. LETELLIER: They were qualitatively compared using tracer objects to map the velocity zones, and --

CHAIRMAN WALLIS: But there isn't the quantitative verification or validation, or whatever you want to call it.

DR. LETELLIER: We felt that the pedigree of the codes for doing open channel flow was sufficient, given a qualitative comparison. We observed the same transport behavior of the fine debris as would be predicted by the velocity patterns.

MR. CARUSO: Did the people that did the CFD modeling know what the tests -- know the test results?

DR. LETELLIER: Of course. They were performed at the same time.

MR. CARUSO: Did they know the results of the test before they did the modeling? Was it a blind calculation, or was it an open calculation?

DR. LETELLIER: As a matter of protocol, the calculations and the tests were not conducted independently. But as a matter of practice, there were no initial conditions presupposed in the calculation that were defined by the test, except for the volume of water that was introduced and the geometry. I personally performed the calculations, and there was no intent to fine tune the calculations.

MR. CARUSO: I'm not asking about intent. I'm asking, did the people that did the calculations know the results of the experiments before they did the calculations?

DR. LETELLIER: The answer is no. The calculations were performed before the velocity mapping was done in the tank. And then, the qualitative comparison was performed. There wasn't a rigid protocol followed for blind assessment in that manner. But the calculations preceded the tests.

There are a number of references available that describe debris transport. The most current are listed as the NUREG-6882 in the middle, small scale tests for separate effects characterization, and then also 6773, the integrated tank tests that incorporated rotational flows and a scaled geometry.

And at the bottom, I mention the peer reviewed articles that appear in Nuclear Technology.

DR. CHANG: Okay. The next slide is about sump screen head loss. When you have the collection of those debris at the sump screen, the next step is to consider the head loss.

In the Reg. Guide, we have the following positions. For the fully submerged sump screens, NPSH available should be determined from the conditions specified in the plant's licensing basis. But for the partially submerged sumps, both in Appendix A and also in Section C.1.3.4.4, we have the same statement.

That is, pump failure criteria should be assumed to occur when the head loss across the sump screen is greater than half of the submerged screen height or the NPSH margin. Either one, whichever is worse.

And then, estimates of head loss caused by debris blockage should be developed from empirical data. You have to have -- to do tests on those.

CHAIRMAN WALLIS: Do you see, though, what I mean about in the second bullet --

DR. CHANG: Yes.

CHAIRMAN WALLIS: -- you've got the screen, and it's behaving like a dam, and there's a loss there. And then, you've got the NPSH, and nothing -- isn't the loss across the screen -- doesn't that actually decrease the NPSH as well? It's not as if it's one thing or the other.

DR. LETELLIER: Calculations of NPSH generally start at the screen location. They account for the static head above the pump. They don't account for friction losses on flow paths preceding or prior to arrival at the sump. They do account for friction losses in the plumbing in the piping.

CHAIRMAN WALLIS: They do account for this loss through the screen, then, don't they?

DR. LETELLIER: The traditional definition of NPSH does not account for pressure loss, pressure drops, across the debris bed. That's being incorporated now as a point of comparison. If the pressure drop is greater than this failure criteria, then you will lose NPSH.

MEMBER RANSOM: Is it true, then, that you're just calculating the hydrostatic head available at the pump over and above the vapor pressure or the fluid?

DR. LETELLIER: Essentially, that's right, with various regulatory arguments about credit for containment overpressure.

CHAIRMAN WALLIS: What's the argument again about this half of submersed screen height?

DR. LETELLIER: I need a diagram in order to illustrate. But you can imagine a vertical screen that's only partially submerged.

CHAIRMAN WALLIS: All right.

DR. LETELLIER: There's water on both sides of the screen, and debris is building on one side.

CHAIRMAN WALLIS: All right.

DR. LETELLIER: The pump is demanding a constant volumetric flow.

CHAIRMAN WALLIS: So there's a drop in level from one side to the other.

DR. LETELLIER: Yes, as the debris builds up.

CHAIRMAN WALLIS: Right.

DR. LETELLIER: But most importantly is if you cannot satisfy the volumetric flow, if there's not enough static head in the pool to force water through the bed, then you will -- your level will drop catastrophically, and you will lose NPSH.

The only pressure available to push water through the bed is the static head of the pool. And on average, averaged across the bed, you have approximately one-half the --

CHAIRMAN WALLIS: Well, that means you'll simply suck the downstream part dry.

DR. LETELLIER: That's correct. As that level drops, you will lose NPSH by definition, because it's dominated by the static head above the pump inlet.

MEMBER RANSOM: What's magic about the one-half, though? Is that the limit of the pump's capability?

DR. LETELLIER: No. You have no mechanical advantage, because the pressure is equal on each side of the screen.

MEMBER RANSOM: No. But what I meant is, the pump only cares about what NPSH is available before it starts cavitating. So is the minimum NPSH, then, roughly half of the available head at the pump inlet?

DR. LETELLIER: No. The definition of NPSH from the point of view of cavitation is defined entirely separately.

MEMBER RANSOM: I know that. But why are you using the factor of a half?

DR. LETELLIER: Because there are two failure mechanisms. You can -- if you lose margin, you may cavitate, or you will cavitate at the pump. One realistic sequence for losing margin is a debris blockage that cannot satisfy the volumetric flow.

CHAIRMAN WALLIS: Even with the NPSH satisfied, the pump is working fine.

DR. LETELLIER: That's correct.

CHAIRMAN WALLIS: It just sucks all the water out, and it can't get back in.

DR. LETELLIER: That's correct.

MEMBER SIEBER: The NPSH disappeared.

DR. LETELLIER: And eventually you will lose NPSH, because your pump is --

CHAIRMAN WALLIS: You'll ingest air.

DR. LETELLIER: -- not running. You're ingesting water there. That's right. And so we're suggesting that you need to examine the minimum of these two criteria, both the NPSH -- because one leads to the other. If, for example, the one-half pool depth is less than the NPSH margin, if you have less than one -- if you have a pressure drop that exceeds one-half the submerged screen area, you will eventually lose margin. One precedes the other.

MR. ARCHITZEL: It's essentially

equivalent to the mid-loop operation in PWRs. When you get below mid-loop, you lose it.

MR. CARUSO: You have on page 6-2 of the -- do you have a copy of the --

DR. LETELLIER: Yes.

MR. CARUSO: -- knowledge base there? Page 6-2, you've got sump configurations. What sort of sump configuration are you talking about that would apply here? We all have copies of this. Page 6-2.

DR. LETELLIER: None of these figures actually show the water level. But if you look at E, the box type filter that has a vertical screen, the case that we're talking about is where the water level is only perhaps halfway. It has only submerged half of the screen, and the upper portion is open, so that you have containment pressure on both sides of the screen.

MR. HSIA: Bruce, can we go to --

CHAIRMAN WALLIS: And you can pump it out from the place faster than it can come in through the screen.

DR. LETELLIER: That's the motivation for the failure.

MR. HSIA: There's a better picture in the Reg. Guide.

DR. CHANG: Figure A.3. That shows the --

CHAIRMAN WALLIS: 3.6.1. is okay. E is okay, too. You can pump it out faster than it can get in by gravity through the screen.

DR. LETELLIER: That's correct.

MR. CARUSO: Do you allow them to calculate how it's going to build up and overflow as a function of time? I mean, there's always water pouring in, and gradually the water levels rise. Is that permitted?

DR. LETELLIER: I think that was the point of one of the comments that was made. And, in fact, we did --

DR. CHANG: Yes. As a function of time, we said, that you can consider this is -- right.

DR. LETELLIER: If they choose to do that.

CHAIRMAN WALLIS: So you might recover the pump again. I mean, as the water rises.

MR. CARUSO: As the water rises.

CHAIRMAN WALLIS: If it's not destroyed already.

MR. ARCHITZEL: But that was principally for like the plants that start spray very early and don't have that level yet. So they need to have a very -- it's not the full flow rate. It would be like an ice condenser that's starting to spray early. The water is very low. They started right at -- initially. Not all the plants do that.

DR. LETELLIER: So we continue?

DR. CHANG: Bruce, yes.

DR. LETELLIER: So we continue with slide number 34.

CHAIRMAN WALLIS: It's the thin bed.

DR. LETELLIER: The final step of vulnerability assessment is head loss across the screen, given a presumed debris bed. And the head loss correlations that are -- it's shown generically below the figure, was developed for 6224 and validated against test -- experimental data for a limited combination of debris -- the predominant combinations of fiber, RMI, and particulate.

This figure shows the range of head loss on the vertical axis that would be incurred as a function of bed thickness, essentially fiber volume, for a given screen. There are assumptions here of velocity and area.

CHAIRMAN WALLIS: It's a very strange curve. You put in more fibers, you get less head loss.

DR. LETELLIER: One of the limitations of the correlation is the assumption of a homogenized bed. And if you have a large fiber volume that's well mixed with particulate, it allows greater porosity, more flow area, and so the head loss is lower than if you have a very thin contiguous bed of fiber. The thin bed, one-eighth inch --

CHAIRMAN WALLIS: This is with a certain constant amount of particulates and more fiber dilutes than particulates? Is that the idea?

DR. LETELLIER: Each curve represents a different mass of particulate.

CHAIRMAN WALLIS: Okay. So more fiber dilutes the particulates.

DR. LETELLIER: That's correct. So you can see the reason for the minimum.

CHAIRMAN WALLIS: It shows that it isn't as simple as you think. And also, the compressibility -- the degree to which the pressure drop across the bed itself compresses the fibers has a big effect here.

DR. LETELLIER: And that's accounted for in the correlation.

CHAIRMAN WALLIS: Right. But if the fibers happen to be squishier than predicted, they can really clog up the --

DR. LETELLIER: That's correct. And that is a phenomena that we observe in some debris types. Calcium silicate, in particular, tends to reweld into a contiguous obstacle.

CHAIRMAN WALLIS: It concerned me a bit about other chemical products produced in the sump that will make this stuff gooier or whatever.

DR. LETELLIER: That's true. And if we have time to share the summary of chemical testing, you'll see that we are not confident that the 6224 correlation is robust for those debris types.

Of all of the steps of the accident sequence, I'd have to say that the head loss has been investigated in the most detail largely due to the amount of work that the industry did to actually design and test the strainer retrofits for the BWR resolution. There is a large body of information that became available at that time.

The head loss correlation has been implemented in a PC utility called BLOCKAGE. It's available for use by the public. It actually has some amount of verification and validation that's documented in the user's guide. It did not adhere to a formal software quality assurance plan, but they were conducted separately.

The code results were recorded separately in separate programming language, and then the results were verified. And then, the output from BLOCKAGE was exercised against all available test data to show the validation steps.

It's important that the head loss correlation be used with appropriate material properties. And, again, the database is not all inclusive. There are materials out there that have not been tested.

It's important that the -- that any alternative correlations be validated through comparable test procedures. The NRC work has established an expectation of quality and level of procedure and attention to detail that should be typical in any alternative method that's proposed.

Ultimately, if these head loss correlations are implemented to validate a new test -- or, I'm sorry, a new design of the strainer, then performance tests of these designs should be done comparable to what was done for the BWR resolution.

The head loss references on page 36 again mention 6224, which I wanted to remind you was actually issued as a draft NUREG. So it was subject to public comment, and the resolution is documented in the appendix to 6224.

DR. CHANG: There are about 80 pages of the resolution of comments in this document, so it's extensively -- being extensively reviewed.

CHAIRMAN WALLIS: You don't consider the mechanism where the fibers sort tangle up on the screen? If anybody has cleaned out a drain from a shower, they noticed the hairs, though the screen is pretty coarse. It's very simple. It doesn't take all that many hairs to tangle up around there and block it up.

DR. LETELLIER: Yes, certainly. We have demonstrated that the thin bed can be established on screens as large as --

CHAIRMAN WALLIS: It's not just a bed. I mean, it can be actually something that goes around the -- extends downstream from the filter itself.

DR. LETELLIER: That's true. And it does -- you do incur some amount of head loss because of that, but the greater concern is a contiguous map.

CHAIRMAN WALLIS: Right. So are you finished now with your presentation?

DR. LETELLIER: So T.Y. has some closing --

CHAIRMAN WALLIS: Yes. My colleague Dr.

Rosen has to go in about five minutes.

MEMBER ROSEN: Yes.

CHAIRMAN WALLIS: Do you have something you would like to --

MEMBER ROSEN: Yes. Presumably, we'd go around the table at the end and get -- have some committee discussion. I beg your indulgence to just listen to my one comment, and then I have to go.

And that is that of all of the -- and I've stayed fairly close to this. I went to the PWR workshop in Baltimore. The committee agreed with me doing it, and I did do it, and you'll soon get my trip report.

But the thing that -- the only jarring thing I heard today that was new was that there is no plan by the industry to deal with -- in the guidance with material that goes through the sump subscreen, how one does -- what one does to analyze that. And that seems to me an open circuit in the protocol that's being developed.

We'll get to the very end of it, and then that question will be asked, and there will be no answer except -- I don't know what. Maybe John Butler of NEI or someone else could help me with that. But I guess I didn't really hear the answer to that.

That's my input.

CHAIRMAN WALLIS: When will we get your trip report?

MEMBER ROSEN: Well, it's done, and it ought to be -- I've given it to the staff.

CHAIRMAN WALLIS: It might help us with the letter that we're supposed to write to --

MEMBER ROSEN: Well, the trip report was rather, you know, brief and preliminary. So I'm not sure it will be much more than you heard here. I think you might just want to, you know, scan it.

MEMBER RANSOM: Who did you send it to?

MEMBER ROSEN: Sherrie.

CHAIRMAN WALLIS: Okay. Well, are you going to finish up?

DR. CHANG: Yes, the last one. In closure, I just want to describe the ongoing research activities under Generic Safety Issue 191. There will be a meeting before the end of October this year. We have two test reports coming out. One is the calcium silicate head loss test report. The other one is some very preliminary chemical tests done for the --

CHAIRMAN WALLIS: Are you going to test just the kind of chemicals that might be in the sump and at the temperatures that they might be at or --

are you going to test the paints and things that might be there?

DR. LETELLIER: We can go through the --

CHAIRMAN WALLIS: So we can get on to some of these questions about --

DR. CHANG: Yes. Bruce has some slides here.

DR. LETELLIER: If you'd like to go through the summary, there's better information.

DR. CHANG: And long term is up to end of fiscal year '04. We plan to have a debris sample characterization of PWRs. There we tried to collect sample latent debris from five volunteer plants, and then we tried to do some additional head loss tests on them. And we plan to have HPSI throttle valve clogging study as well. And the --

CHAIRMAN WALLIS: Can you do something about this zone of influence issue that seems to be of some concern? And if there's anything you can do from what's already happened in Barseback, and so on, to see, was it a directional jet, or was a spherical thing, or anything that would help to give some realism to the zone of influence model, that would really help I think. I'm suggesting that you do that.

DR. CHANG: I don't know if Barseback --

they still have all this information available or not.

CHAIRMAN WALLIS: This report lists a lot of things that are described, but then someone should go in and say "ah ha." Now, from what I saw, what the description is, this shows that it is a jet or something -- something you could deduce from it that helps your model.

DR. LETELLIER: Those aspects can be revisited. I rather doubt that there will be any --

CHAIRMAN WALLIS: But try.

DR. LETELLIER: -- new inspiration that comes forth.

CHAIRMAN WALLIS: But you have an ongoing contract, do you? You can do this?

DR. LETELLIER: I'd be happy to do it. I just need some direction.

MEMBER SIEBER: Well, did the Ontario hydrotesting tell you anything? That was actual configurations with varying types of insulation.

DR. LETELLIER: Those were free jet expansion for two-phase flow. They were very similar to the air surrogates that were performed for the BWR study.

MEMBER SIEBER: So they don't tell you much about energy distribution in a compartment.

CHAIRMAN WALLIS: Didn't the University of New Mexico -- they did a test where they had a pipe with insulation on it, and they took a two-phase jet and directed it at it?

DR. LETELLIER: That was actually done as part of the BWR.

CHAIRMAN WALLIS: But that's not a spherical jet. That's a directional jet.

DR. LETELLIER: That's correct. And it was done for the purpose of measuring the damage pressure, so that we know what the vulnerabilities of each insulation type are.

CHAIRMAN WALLIS: Yes. But then, you didn't go back and say, "Now, if we had assumed it was a spherical jet, what would we have got for the predicted pressure."

DR. LETELLIER: Had we done that, we would have been taking credit for dissipation that we didn't show.

CHAIRMAN WALLIS: Yes. It seems to me that you're doing a test which is at odds with your whole model for zone of influence.

DR. LETELLIER: I don't quite understand the comment. We are remapping the equivalent damage volume into a sphere as a practical simplification, in light of the fact that our targets are distributed rather homogeneously throughout containment.

CHAIRMAN WALLIS: Well, I guess we'll revisit this again. I'll get back to the firehose and the -- you know, the firehose -- the purpose of the firehose is to go in one place. It's very different from the spherical.

DR. CHANG: Bruce, do you want to go into your second subject?

DR. LETELLIER: Yes.

DR. CHANG: Bruce would like to share with us some of his ideas about other alternatives.

DR. LETELLIER: Let me ask the committee what your preference would be and your time constraints. We are --

CHAIRMAN WALLIS: Tell us what's important in a short time. We don't have to go -- I don't think my colleagues have to go exactly at 12:00, so we can go at, say, 12:30 or so.

DR. LETELLIER: We're here at your convenience. We have two topics that --

CHAIRMAN WALLIS: Well, if you had 20 minutes, could you tell us the most interesting stuff here?

DR. LETELLIER: My personal opinion is

that the chemical effects testing is the most interesting.

CHAIRMAN WALLIS: Okay.

DR. LETELLIER: I think you can browse through the set of handouts on sump operability strategies and see what conceptual concepts that you could put on a table in a brainstorming context. The fact that we're presenting these does not imply any endorsement, practicality, or operability of these concepts.

But we hope to show you that the industry is not without options. There are a number of things that can be pursued through --

CHAIRMAN WALLIS: We can look at these pictures, and we can sort of see how they might work.

DR. LETELLIER: Exactly. That's the intent.

CHAIRMAN WALLIS: So now you want to tell us about the chemical --

DR. LETELLIER: Give me a moment to pull up the slides. And I apologize, I don't have handouts for you. Those can be provided after the briefing.

MR. ARCHITZEL: I've got an ADAMS number if you want it. It's already in ADAMS. It's the same slides you did at the --

DR. LETELLIER: It's a condensed set. This is essentially the information that was presented at the workshop two weeks ago.

MR. ARCHITZEL: Workshop slides are available in ADAMS.

DR. LETELLIER: Have members of the committee looked at those slides --

CHAIRMAN WALLIS: No.

DR. LETELLIER: -- already?

CHAIRMAN WALLIS: No, I didn't.

MR. HSIA: I think it would be more appropriate -- when we are complete with the chemical testing, there will be a report issued, and at that time we can come back, if you choose, to present to you a complete picture.

CHAIRMAN WALLIS: But the fact that you're saying there are chemical reactions that produce precipitants indicates to me that there are chemical reactions which produce significant stuff. And it may not always be in the form of nice, dry -- dry-type particulate stuff. It may be gooey or bubbly or something, depending on what's going on chemically.

DR. LETELLIER: That's correct. And we can show you the status of our investigations. We've been looking at this for the past three or four months over the summer.

We had a rather limited scope to assess the plausibility of these various chemical reactions, exacerbating head loss on the screen. All of this work is also being done at the UNM Civil Engineering Department in their hydraulics lab.

The motivation for the work -- you're well aware of concern of the committee regarding gelatinous material observed in TMI. Try to focus on determining where this material came from and if it's a plausible concern for reactor accident sequences.

CHAIRMAN WALLIS: Now, this stuff that sprays out from the reactor is borated water. So when it hits the stuff out there in the containment, it's boric acid. When it gets in the pool, it gets diluted with sodium hydroxide. Is that the way I understand it? It gets turned to a high pH in the pool.

DR. LETELLIER: Your chemical injection tanks that actually increase the pH -- there are sodium hydroxide injection tanks, and the boron concentration in the RWST is much different than is present in the RCS.

CHAIRMAN WALLIS: But they don't inject into the reactor system. They inject into the containment somewhere?

DR. LETELLIER: Yes, they do. They are part of the spray and also the --

CHAIRMAN WALLIS: But they don't inject into the RCS. The RCS is borated, acidic, low pH stuff. So the jet that hits the walls is acidic, and then it has a chance to do its acidic reactions. It runs down the wall, and it meets this alkaline stuff, which has come from somewhere else, and the spray, which has fallen down from the roof.

MEMBER SIEBER: The reaction actually occurs in the containment atmosphere.

CHAIRMAN WALLIS: It can as well. I think it's -- there's some uncertainty. But the jet -- if the jet's direction is certainly acidic, and it sputters acid all over the wall --

DR. LETELLIER: That is a detail that we have not examined as yet -- the time dependence of the concentrations. We've looked at more the homogenized solution of the containment pool, what would be -- in particular, how the spray RWST impacts the water chemistry, because keep in mind that the sprays impinge on a much larger area of exposed metal than the break jet.

I should state right up front that this is important enough -- we feel it's a very important issue, and we've convened a peer review panel to take place the first week of September. We're not sure what expectations we should meet through this peer review, but we do have outside experts that are -- both represent academia, national laboratories, and the industry, that are not currently participating in the safety -- resolution of the safety issue.

We're investigating several tasks. The scope was broad -- look at chemical effects. We focused primarily on the corrosion of exposed metals with subsequent precipitation. There are other chemical effects. One has been postulated this morning -- hydrogen generation that leads to the formation of bubbles. That was not on our list of priorities.

CHAIRMAN WALLIS: But it's mentioned in your report.

DR. LETELLIER: As I said, it's not on our list of priorities for this limited introductory effort. We were looking at chemical degradation of an existing fiber bed. We're concerned about --

CHAIRMAN WALLIS: Well, the simplest thing you can do -- I guess I could ask the staff here to do it -- is it says here that it's already being used to estimate hydrogen source term. So we could simply take the results of what -- that analysis that has been done, find out how much hydrogen there is.

DR. LETELLIER: That's true. It could be done as an analytic exercise.

CHAIRMAN WALLIS: Find out what that information is. If it's -- it says it's been done.

DR. LETELLIER: I will tell you that none of our immersion samples show evidence of bubble formation. Zinc granules, zinc coupons, paint chips, the generation is not --

CHAIRMAN WALLIS: So they're used in many FSARs to estimate hydrogen source term.

DR. LETELLIER: Yes.

CHAIRMAN WALLIS: So they must be there somewhere. Okay.

DR. LETELLIER: That's true. And because of that work, we do have estimates of exposed aluminum area, because of that need to track hydrogen generation. We have some idea of plant vulnerability regarding exposure area.

MR. ARCHITZEL: I just asked the committee a question on that. If a lot of the hydrogen generation comes off the severe accident source term in the DBA, would that be a factor that we should consider?

CHAIRMAN WALLIS: No.

MR. ARCHITZEL: Well, I mean, you assume a certain amount of fuel damage. It's much more than you get in the DBA.

CHAIRMAN WALLIS: Is that what's done in the FSAR?

MR. ARCHITZEL: Hydrogen generation is coming from the radiolytic decomposition of the water. And if the DBA prevents that, I know we assume that in the DBA. The whole purpose of this exercise -- you've got a DBA, and you've got this -- I mean, there's an opportunity to not consider it based on the fact that you don't -- I know we do consider it for radiological doses.

MEMBER KRESS: This thing is to keep from getting these products in there, and I don't --

DR. LETELLIER: Exactly.

MEMBER KRESS: -- think you want to do that here.

CHAIRMAN WALLIS: There's a different question, though. There's --

DR. LETELLIER: Hydrogen generation does not precede loss of sump.

MEMBER KRESS: No, that's right.

DR. LETELLIER: It's not an initial

condition from our --

MEMBER KRESS: That's right. I don't think you want to do it that way.

MR. ARCHITZEL: I don't understand. I guess I'm just trying to -- I guess my point was there is an opportunity to not consider it because you haven't had the core damage.

CHAIRMAN WALLIS: No, I don't think you can not consider it. It's a chemical effect. I mean, it says it here -- that the aluminum reacts with --

MR. ARCHITZEL: Well, the aluminum -- okay. I thought it --

CHAIRMAN WALLIS: -- the stuff that's in the sump, and it's going to make -- so it makes hydrogen. So I think you have to consider it.

MR. ARCHITZEL: Okay.

DR. LETELLIER: We will review that.

CHAIRMAN WALLIS: Maybe you can't use the numbers for some other calculation to find out how much hydrogen. So maybe what I'm asking Ralph to do is not very helpful. But at least he can look at it and see if we can learn from it.

DR. LETELLIER: A similar issue brings to mind the water chemistry. In a severe fuel damage event, you'll have nitric acid produced because of radiolytic exposure of air.

MEMBER KRESS: Still, you have to have the radiation.

DR. LETELLIER: You have evolution of chlorides from cable trays. But, again, those conditions --

MEMBER KRESS: That doesn't seem to be part of this.

CHAIRMAN WALLIS: We're not looking at radiation here.

MEMBER KRESS: Right.

MEMBER SIEBER: They're longer term.

DR. LETELLIER: Those are longer term, and we've ignored those chemical reactants in our matrix. Schematically, this is the concern that occurs, that the borated solution and sprays impinge on exposed metal surfaces. Metal surfaces are also immersed in the pool, and the metals can be dissolved and suspended as free ions in solution.

If you reach saturation -- and these metals are extremely insoluble -- once you reach saturation, there's a potential for precipitation to occur. The formation of metallic hydroxides, for example, shown in the middle panel -- we've confirmed that, yes, you can produce these effects using background, borated water, and simulated metallic nitrates to induce free metal, dissolved metal. You will generate a precipitant, and it will cause significant head loss.

CHAIRMAN WALLIS: When these zinc ions are running around in this low pipe pH -- now it's high pH, isn't it?

DR. LETELLIER: Yes, it is.

MEMBER KRESS: Aren't these extremely small?

CHAIRMAN WALLIS: Is there a hydrogen production mechanism in there?

DR. LETELLIER: I'm not sure. We have not addressed --

CHAIRMAN WALLIS: But it says in your report that's why --

DR. LETELLIER: Well, I don't have any comment. We have not addressed hydrogen generation.

CHAIRMAN WALLIS: Let's see if there is.

MR. CARUSO: What comes out from the reactor, the spray or -- to create the zinc hydroxide? It's --

DR. LETELLIER: In the middle panel, that's the precipitation.

MR. CARUSO: Actually, it's the left-hand panel, the production of the zinc hydroxide I believe generates hydrogen.

DR. LETELLIER: That may be true. We have not examined that.

CHAIRMAN WALLIS: Well, where does the H go from the water? It presumably gave the OH to the --

MR. CARUSO: That's where it goes.

DR. LETELLIER: Well, keep in mind that this is strongly buffered solution. There's a lot of sodium hydroxide that's available.

CHAIRMAN WALLIS: You're going to sort that out.

DR. LETELLIER: Right.

MEMBER FORD: I guess the thing that -- everything you've said so far is thermal dynamically possible. I'd question the kinetics of the process, whether it's a big deal or not, and --

DR. LETELLIER: That's a very important issue. We have demonstrated that each of these separate effects can occur.

MEMBER FORD: Yes.

DR. LETELLIER: We've demonstrated the linkage between step 2 and step 3. The flocculent material is very transportable. The particulates are extremely fine. They are extremely small, but they also are hydrophilic in the sense that they bind water molecules into a jelly, into a gelatinous mass.

CHAIRMAN WALLIS: What you need to do in your picture is show those green things as zinc and the white things as hydrogen.

MEMBER KRESS: That's what they are.

CHAIRMAN WALLIS: And then, if you take a physical model, the zinc particles and hydrogen bubbles -- and your picture is very good --

DR. LETELLIER: We add the hydrogen bubbles.

MR. CARUSO: Does the concrete have any chemical effect?

DR. LETELLIER: It certainly does. In fact, we added some calcium carbonate to represent the eroded concrete present in the jet.

MR. CARUSO: And what did it do?

DR. LETELLIER: Well, we have not done an exhaustive assessment of the parameters of concentration. In general, it increase the pH similar to the sodium. And, in fact, in that respect it's a buffer solution, and it increases the solubility of the metals, dissolved metals.

MR. CARUSO: So it probably also depends

on the type of concrete, too.

DR. LETELLIER: It certainly would. Containment environments are very dirty. You have a variety of chemicals that are different from our clean test tube, our beaker experiments.

The executive summary we have already hinted at. Metal corrosion is credible for the borated cooling water. The UNM test confirmed the literature reported values for room temperature. They are typically reported in units of grams per hour per square meter of exposed metal.

But for the elevated temperature, we did oven tests at 80 degrees C, just to represent a substantially higher temperature. We were not able to confirm the reported rates of 11.3 grams per hour per square meter. Those are extremely high rates, and we believe that the kinetics are an important aspect of this inconclusive test at the moment.

We are looking at immersion and corrosion in a quiescent beaker that's not subject to flow mechanisms of any kind. And we think that there's a surface catalyzed redeposition of this material. It's not freely released to the solution so that you gradually reach saturation. It's affected by the very high local concentrations near the substrate, and I'll show you a picture of what that corrosion product looks like.

CHAIRMAN WALLIS: Now, in terms of breaking off flakes of paint, does the boron in the water help to loosen up the flakes?

DR. LETELLIER: We haven't examined that issue. We are looking at paint as a debris source that's liberated in the zone of influence. The industry guidance and the best available NRC guidance is to assume 100 percent destruction of paints within the damage zone. We have not looked in depth at the chemical effects on those paint chips.

We are concerned about the potential to leach the zinc from inorganic primers, because that's a significant reservoir of metal, for example. And we do have some very preliminary tests, qualitative in nature, that I wasn't prepared to present.

The second bullet in blue -- we have confirmed that the low solubility of these metals does lead to precipitation if you exceed the saturation threshold, and that the chemical precipitate does lead to a substantial head loss in combination with fiber on the screen.

Ultimately, the plant vulnerability depends on the connection between corrosion and precipitation, and that really needs to be established by an integrated test that we haven't done yet.

To get into the details of how the test procedure was conducted --

CHAIRMAN WALLIS: Well, let me ask you here. Suppose that these chemical effects are important. We don't seem to have a knowledge base for industry to respond to the question about, do they have a significant effect on their plant? So what's required to get that knowledge base? I would presume NEI isn't going to create it out of nowhere. It's not there.

DR. LETELLIER: We're in the process of creating the knowledge base, and our October report will be the first --

CHAIRMAN WALLIS: So, again, it's one of these things where you can't do the analysis, because you don't know yet. So we don't do anything.

DR. LETELLIER: Well, I'm not sure that's true. I mean, I showed you a corrosion rate that's reported in the literature. It's very high.

CHAIRMAN WALLIS: It is.

DR. LETELLIER: It will lead to many hundreds of pounds.

CHAIRMAN WALLIS: Orders of magnitude

bigger than you observe.

DR. LETELLIER: Yes. But, in fact, that's the best available evidence at this moment. And the conservative approach is to adopt that corrosion rate with some estimate of exposure opportunity, and assume the connection between corrosion and precipitation.

MEMBER FORD: In your knowledge-based report, this one here, you mention in one of the -- some of the plants that have seen blockages. Sludge was talked about, in which there was metal corrosion plugs. What metal was it?

DR. LETELLIER: Well, in the BWRs that have a suppression pool, the sludge is predominantly iron oxide. It's rust. And, in fact, during the BWR study, that debris source dominated considerations of additional dust that might be present, because there is so much iron oxide.

And the correlations were tailored to perform best with that type of debris. There were no considerations of the chemical precipitants at that time.

Let's skip to some information about how the precipitation tests were conducted. We started with the ionized water supplemented with our boron concentration, representative of actual plant configurations. It was not done in the detail that you alluded to. It was meant to describe the gross -- the bulk mixed concentration.

We established a fiber bed in a closed loop test apparatus, and then we introduced a metallic salt in order to force the precipitation to happen. We essentially introduced more -- we introduced enough metal to exceed the saturation threshold, and then we observed the results.

MR. CARUSO: Why did you pick those particular chemicals?

DR. LETELLIER: We were mostly interested in the metals, because there are exposure opportunities for iron, aluminum, and galvanized cable trays represent zinc. We could also have used copper, lead, etcetera. Those are the vulnerable materials in containment.

We use the nitrate as a convenience for introducing dissolved metal. We could prepare a stock solution, essentially.

CHAIRMAN WALLIS: Did you have -- you didn't have flakes of zinc paint and stuff in there, but --

DR. LETELLIER: Not in these tests. That's correct. These are some of the test samples that are arrived at from different concentrations of iron and zinc. In the next slide, I'll show you the data that all of these metals --

CHAIRMAN WALLIS: We are looking at little buttons of stuff which got eaten by --

DR. LETELLIER: We're actually looking at the test samples about four inches in diameter.

CHAIRMAN WALLIS: They obviously got eaten by something. They got corroded, didn't they? Isn't that what we're seeing?

DR. LETELLIER: No. Let me clarify.

CHAIRMAN WALLIS: It looks like artifacts from an archaeological dig or something.

DR. LETELLIER: They look like jellyfish. Keep in mind that we introduced clean fiber into a test section that's about four inches in diameter. We put in 100 grams of fiber, which is essentially yellow insulation. And to this test column we introduced the metallic nitrate, induced the precipitation, and we measured the head loss.

CHAIRMAN WALLIS: So you made zinc precipitate on the fiber in some --

DR. LETELLIER: Yes, we forced it to precipitate.

CHAIRMAN WALLIS: And you made this

gooey --

DR. LETELLIER: Yes. These are the test samples of the bed that was recovered from each test.

CHAIRMAN WALLIS: -- cookie dough type stuff. Is that right?

DR. LETELLIER: Right.

CHAIRMAN WALLIS: Well, that's the sort of thing we thought might happen, or could, you know? Needs to be considered.

DR. LETELLIER: We can certainly create those conditions in a confined environment. It is plausible.

These are the data, head loss being shown on the vertical axis, and the effective concentration of each metal along the abscissa. The blue line shows you the baseline. That's the head loss incurred by the fiber alone, by itself. And then you can compare the margin that was measured.

CHAIRMAN WALLIS: It's just like the precipitates from the soap that gum up your drain. It's not just the hairs. It's the other things that get in with them.

MEMBER SIEBER: That holds the hair together.

DR. LETELLIER: That's right. And that's

an important factor. You should understand that the head loss that we're observing here is much, much greater than you would observe from an equivalent amount of dry particulate. It's much different than the 6224 correlation.

The threshold of about 10^{-3} molar is the threshold for the saturation threshold. That's where we first start to observe the effects. The concentration axis really represents additional mass that we've added to the bed, and that's why the pressure -- the head loss trends are consistent between materials.

MEMBER KRESS: That's the concentration you would have had if you added that mass and none of it precipitated?

DR. LETELLIER: Yes.

MEMBER KRESS: Okay.

DR. LETELLIER: That's right. But, in fact, all of it precipitated.

MEMBER KRESS: Yes.

DR. LETELLIER: And all of it arrives on the bed.

Now, just to give you some engineering chemistry facts to kind of baseline your understanding about this, first of all, you understand that every metal has a different molecular weight. But if you look at this block, the threshold for precipitation of about 10^{-4} molar is equivalent to several tens of pounds in a million gallons of water. That's not very much material. And, in fact, most large drives don't have a million gallons.

CHAIRMAN WALLIS: The amount of hydrogen needed to float that stuff, because hydrogen is so light, is even less.

DR. LETELLIER: Perhaps you're right.

CHAIRMAN WALLIS: It doesn't take many models to --

DR. LETELLIER: Keep in mind that the precipitation -- the precipitant -- it might serve as a nucleation site for bubbles.

MEMBER KRESS: And now that was a log scale on concentration.

DR. LETELLIER: Yes.

MEMBER KRESS: And so you're going up a factor of 10. Do you have that much available compared to the amount of water you have?

DR. LETELLIER: Well, keep in mind, your observation was exactly correct. These are the concentrations that would exist if there was no precipitation. But, in fact, once you reach the threshold, it does precipitate.

MEMBER KRESS: So it's a continuous --

DR. LETELLIER: Yes, it is a continuous process. And so this concentration really represents the amount of material that we force on the bed. It's directly proportional to the mass on the bed.

MEMBER KRESS: Okay.

DR. LETELLIER: Now, in this block, at 10^{-3} molar, the amount of material that we actually added to our 10 liter closed loop is very small -- fractions of a gram -- .3 grams of aluminum were added to this test volume.

And we are actually inducing seven to 10 feet of head loss with just a fraction of a gram. That's much, much different than you would expect from an equivalent mass of dry particulate.

I did not bring the electron micrographs of the debris bed. But you can see that the precipitant tends to stick or adhere to individual fibers, and it changes the hydraulic flow characteristics of the bed.

Dry particulate, by contrast, tends to lodge in the interstitial space and obstruct the flow area. So there's a quite different mechanism going on.

Also, our observations of the jelly-type layer give you the impression that it's taking up a much larger volume than would be assumed by those fractions -- fractions of mass. So the precipitant is actually hydrophilic.

CHAIRMAN WALLIS: That's what gels do.

DR. LETELLIER: Exactly. It binds water molecules into a gelatinous mass.

CHAIRMAN WALLIS: Which really makes me feel good.

MR. CARUSO: I'll tell you where there's a lot of information about this, and that's in the filtration industry. And I'm -- probably every plant in the United States, every nuclear plant in the United States, has a chemical waste treatment building that has a whole bunch of filters in it with pre-codes, and all sorts of techniques like that to do exactly what you're trying to measure. And the people that sell those machines know all about how this works.

DR. LETELLIER: That's exactly right. For the final steps of water quality treatment, for clarification they add an aluminum nitrate coagulate.

MR. CARUSO: Flocculents.

DR. LETELLIER: Exactly.

MR. CARUSO: And somewhere in every plant there is a chemical engineer that runs that waste treatment plant that knows all about this chemistry. You've just got to get that guy out and talk to the thermal hydraulicist.

DR. LETELLIER: But keep in mind this is the kind of chemistry that you do not want inside a containment during accident. So there is a disconnect in the application of their expertise. But you're right; there's a large body of information available.

MEMBER SIEBER: It's the same process, though.

MR. CARUSO: The same process.

DR. LETELLIER: Yes.

CHAIRMAN WALLIS: Well, I think you've convinced at least me that this is something that needs to be considered in resolving this issue of some --

MEMBER SIEBER: It may go beyond that. This may be the overarching consideration.

DR. LETELLIER: Let me introduce one more observation from the tests that are not so conclusive. When we tried to confirm the dissolution rates at high temperature, we assumed that corrosion would happen in a more or less uniform manner until you reached that saturation, and then the precipitate would form.

But, in fact, we never reached saturation. We started to produce a secondary corrosion product that recrystallized on the metallic substrate. And this may be an artifact of our very quiescent beaker where, in fact, you cannot remove the dissolved metal that's free to enter the solution. You're dominated by local concentration effects.

But, in fact, the corrosion is evident at high temperature. Shiny zinc granules turn black, and they tend to gain mass, in effect, leading us to suspect that there's a secondary chemical reaction that's binding either nitrogen from the air, dissolved air, carbon from the air, oxygen, something -- and we're working to analyze the composition.

CHAIRMAN WALLIS: When they oxidize in this solution, they take the oxygen from something, presumably.

MEMBER KRESS: OH.

DR. LETELLIER: From the water.

CHAIRMAN WALLIS: What's left behind?

MEMBER KRESS: H_2.

DR. LETELLIER: These corrosion products have a very interesting crystalline structure. There are a couple of different formations. The very -- the small fine platelets that are well organized crystal structure, and there's an alternative which is the large puff balls, for lack of a better word.

The compositions of those two crystals are very similar. We've done an electron X-ray spectrum analysis as a byproduct of the electron micrograph. You get an excitation signature from electron shells, and you can look at the X-ray spectrum and identify composition. And we've done some of that.

I didn't choose to present it, but it's helping us understand the composition in hopes that we'll pin down the formation -- the mechanism for formation.

CHAIRMAN WALLIS: Is this the picture of the black stuff on the tiny zinc particles?

DR. LETELLIER: Yes.

CHAIRMAN WALLIS: So the size of this is actually still small compared with the particle itself. The size of these --

DR. LETELLIER: The scale of the white bar at the top is 20 microns.

CHAIRMAN WALLIS: But the size of these growths --

DR. LETELLIER: Very small.

CHAIRMAN WALLIS: -- barnacles and all,

they're very much smaller than the size of the big particle itself.

DR. LETELLIER: Yes.

CHAIRMAN WALLIS: So it's not as if it grows very big as a result of this.

DR. LETELLIER: That's correct. And, unfortunately, this material is quite frangible. It comes off. It's brittle, and it -- depending on further testing, it may represent a new debris source.

CHAIRMAN WALLIS: Another concern, you know, might be if it enabled the particles to hook up together or something, if you stick them together, make some other structure.

DR. LETELLIER: Perhaps.

CHAIRMAN WALLIS: Anyway, very interesting.

DR. LETELLIER: So our status to date -- we've essentially completed all of the experiments that we had proposed under the current scope, and now we're documenting our results that will be released as a NUREG in the October timeframe.

There are significant uncertainties related to corrosion at high temperature. We have two hypotheses that -- either the dissolution is happening so quickly that you reach saturation and immediately deposit into crystals, or you're dominated by surface chemistry. You have a heterogenous reaction occurring that's dominated by the local concentration.

MEMBER KRESS: The 11 grams per hour per unit area, does that come from extrapolating the erroneous curve from lower -- a lower temperature?

DR. LETELLIER: I suspect that it might, and that's the reason that we felt it --

MEMBER KRESS: You can miss those pretty much, depending on how much of the bottom part of the curve you have.

DR. LETELLIER: We felt it necessary to confirm those rates before we proceeded with our assessment of vulnerability.

MEMBER KRESS: Yes. But you're quite right. These local effects could -- local concentrations could have a big effect.

DR. LETELLIER: And I think we could do a better job of this measurement, corrosion rate measurement, if we had a flowing system.

MEMBER KRESS: Yes. Stick a stirrer in your beaker.

DR. LETELLIER: Yes.

MEMBER FORD: The other thing is that you're using zinc as a -- correlated to zinc chromate.

Although some paints do have metallic zinc in them, not many do. It's not zinc chromate. There's an inhibitor, and so you're merely fooling yourselves by doing your experiments on metallic zinc.

But, you know, it would --

DR. LETELLIER: We're also concerned about the galvanized cable trays, which represents an additional source of zinc.

MEMBER FORD: That would be metallic, too, although not entirely. If it's a more modern plant, it wouldn't be zinc, it would be zinc granules.

CHAIRMAN WALLIS: So is there potential here for this thing -- this issue to be sort of resolved by you sending out all of this -- this Reg. Guide, and NEI comes up with a wonderful analysis, and everyone says everything is fine.

And then, in a year or two's time, people have done a little more work with this chemistry and have said, "No, it isn't," because the chemical stuff is much more lethal to the screen than all these fibers or in combination with them. Therefore, you've got to start again. Is there a potential for something like that to happen?

MR. ARCHITZEL: I'll say that industry said no way. They're not going to go to their VP and do this with this issue hanging out there. That was what got --

CHAIRMAN WALLIS: So nothing is going to happen until the chemical issues are resolved?

MR. ARCHITZEL: That was the feedback we got at the workshop.

CHAIRMAN WALLIS: That's what we heard from I think Steve Rosen. He said that because you can't understand what's going on, you do nothing.

MR. ARCHITZEL: I think that was the comment he made, yes.

MR. HSIA: But at this moment, I would like to put a different perspective -- yes, it's true based on the tests we have done so far that there is significant head loss because of the gelatinous material. What we really don't know is how much metal structures or metal parts that could interact with the coolant at lower part of containment.

Even the spray comes on -- there are metals up there. We really don't know how long -- what the effect is. We know the corrosion will be there, but we don't know whether the corrosion will be carried down and start to react. So there are still a lot of questions.

We're not saying at this moment that

plants have problems. All we're saying is if you have gelatinous material. So it's very plant-specific.

DR. LETELLIER: I'd like to point out also in the handout package on sump operability strategies, on the second-to-the-last page, there is a concept of sacrificial screen area, which might be appropriate to mitigating this problem.

CHAIRMAN WALLIS: Yes. There are all kinds of fixes one might devise when one understands enough about what's happening.

DR. LETELLIER: Including chemical balance on the lines of phosphate baskets that were introduced for iodine sequestration.

CHAIRMAN WALLIS: Right. As long as you don't screw up something else by doing that.

DR. LETELLIER: It has to be an integrated safety --

CHAIRMAN WALLIS: I think we're coming to the end here. My colleague Dr. Kress has to leave. I'd like to ask him to give us the benefit of his thoughts at this time.

MEMBER KRESS: Okay. First off, I do think this is a significant safety issue, and I'm glad to see all of the good technical work that's been done so far.

I'm a bit surprised that there is no element of risk-informing this Reg. Guide or risk-informed the rule associated with it. And what I mean by that is I think one could attach probabilities to breaks of different sizes.

And if one had, then, an acceptable frequency of these breaks based on the outcome -- and the outcome would probably be as a release of fission products or something in the long-term cooling -- then one might be able to -- if one had an acceptance value on that, one might be able to eliminate many of the break size based on risk considerations, and get down to a size that may be a reasonable size for screens that we may already have.

So I'm a bit surprised that I don't see that thinking showing up so far. And along the same vein, I think leak before break would be an input in establishing these frequencies. And I'm surprised not to see that.

Another thought is I -- you know, in spite of the comments on reflection off of surfaces, the zone of influence still looks to me like it could use some more thought. I would have guessed, for example, one might have taken the conical shape and just directed it arbitrarily in all different directions and pick out the direction that gave you the most, or something like that.

And I still think it needs some more thought, and I haven't gelled my own thoughts on that.

And finally, I think this life stuff you showed on the chemistry has the potential to be a real showstopper. And I think eventually need to put to rest chemical effects.

Now, I suspect the kinetics may be too slow for this to be real significant, and so I think it's real important that you get through the kinetic effects and actually pinpoint what the potential danger in that is. But anyway, I think you guys are thinking along the right ways, and looking at very important phenomenon. And I'm glad to see some good technical input going into it.

CHAIRMAN WALLIS: Well, that's good, Tom. How about, then, this Reg. Guide -- how does that fit in from the regulatory point of view? Is it going along with all of these -- thinking along the right lines?

MEMBER KRESS: You know, I feel a little bit like Steve. I hate to see nothing being done. And the question is, you know, Reg. Guides are usually living documents. You change them, as you learn more and learn more. The question is: when do you stop learning and put out something that's useful?

I don't know. That's a regulatory decision, and I don't know if I've got much advice there. But personally, I don't think the Reg. Guide is quite far enough along to be ready to go out. But, you know, I think we need to look at it more and look at the NEI document in combination before we can make that decision.

CHAIRMAN WALLIS: Thank you.

It's a bit of a chicken and egg situation, isn't it? I mean, you send out the Reg. Guide and ask for all kinds of things, and this may induce people to do the work. Or you can say, well, they're going to adapt the Reg. Guide. We want to see what work they can do before we fit in the Reg. Guide, so the Reg. Guide fits in with it. And you have different strategies that could be adopted there.

MEMBER KRESS: Thank you, guys. I have to run.

CHAIRMAN WALLIS: Let's see. Tony, do you want to wrap things up, or T.Y., or anyone from the staff?

MR. HSIA: The only thing I want to say is thanks for this opportunity. You have pointed us to several important issues we may not have delved in deep enough. We're going to do that, and that's it. I don't have any other concluding comments.

CHAIRMAN WALLIS: Thank you.

MR. HSIA: Thank you.

MR. BUTLER: I feel compelled to make some clarifying statements on what industry is doing to address this issue. I do not want to leave the ACRS with an impression that the industry is not doing anything to address the issue awaiting final resolution on the chemical effects. We are doing a number of actions, what we can do right now with the information we have.

We just completed a workshop. We are doing -- individual plants are doing walkdowns to assess their inventory of possible debris sources, to address their layout, to get as much information as they can, such that when they're given a go-ahead to do the evaluation, they can do that.

The concern expressed at the workshop mentioned by Tony earlier was that the final resolution, the final fix, it would be very difficult to go to a VP right now and say, "We need to install a 600 square foot passive screen" without knowing the effect of the -- of that solution -- of the chemical effects on that solution.

So without having a little bit more information, we -- you know, we're -- the final resolution may be delayed until we have that information. So what we're going to do is meet with the staff on -- in September to discuss what research, whether it be NRC sponsored or industry sponsored, is necessary to get the answers as quickly as possible.

CHAIRMAN WALLIS: Will you have the September -- the guidance you were going to put out ready in September, with this chemical issue as something to be done later? Or what?

MR. BUTLER: We're hoping to get that out as -- end of September, maybe a little bit later than that. Whether or not we have the chemical effects addressed in that completely or --

CHAIRMAN WALLIS: Okay. So we'll --

MR. BUTLER: -- as just a placekeeper --

CHAIRMAN WALLIS: We'll have something to look at, then.

MR. BUTLER: -- we'll have something to look at, yes.

CHAIRMAN WALLIS: As far as the physical effects.

MR. BUTLER: Yes. Again, we're not trying to hold this up. In fact, we're trying to speed the resolution up as much as we can, because this is a costly item just to keep following this. So resolution is sought by all parties.

Thank you.

CHAIRMAN WALLIS: Thank you.

So I think I will thank you, presenters, from the staff and from Los Alamos. And I'll turn to my colleagues, yes, for their input.

Do you want to start, Peter?

MEMBER FORD: Sure.

CHAIRMAN WALLIS: Are you ready to go?

MEMBER FORD: I thought the Reg. Guide and the associated materials that were given to me, they recognize all of the constituent parameters in the sequence of events leading up to sump blockage and loss of NPSH.

I think we recognize all the relevant ones. The only question, of course, is chemical and precipitation. And I agree with Tom; I think that the kinetics of the process may well assure that it is not a major one. It has to be tested.

It gives good advice as to how to tackle the analysis of the various specific effects, individual effects, in the debris source and transport, etcetera. My concern is that there is no quantification of the integrated effects between those various parameters.

And the validation of that quantification against what was observed at various plants -- and those plants are itemized in this knowledge base report. And, therefore, I can't see how the licensee can demonstrate that they can avoid the failure criteria that is given in Appendix A.3 or the Reg. Guide.

The reality is, however, that it will take I think a fair amount of work by the licensees, NEI, EPRI, or whoever it is, to demonstrate that they can meet those criteria in A.3.

I'll be very interested to see what NEI comes up with in September as guidance to their customers. I think that the Reg. Guide should be issued now in its current form, with the proviso that work is done by the industry to resolve these outstanding questions.

I don't know how that is done, procedure-wise or procedure process. But I think it is a safety issue, and it should be -- we can't just wait forever for these outstanding questions to be answered.

CHAIRMAN WALLIS: Thank you.

Jack?

MEMBER SIEBER: Okay. I'll be brief. This is Rev. 3 of this Reg. Guide, and I am certain there's going to be a Rev. 4, because I don't think that this represents a complete investigation of all of the effects that are important in the sump blockage issue.

I don't know, but my feeling is the chemical effects is an important phenomenon. And I've done some work, but I'm struck by the fact that I think that it may be the overriding effect that's based on some simple things that I've seen in my career.

And I think it's important when you do it that you actually, instead of looking, for example, at elemental zinc that you test based on the compounds that you will find in containment, so that you get the right reaction instead of saying, "Well, I tried sodium hydroxide and a coupon of zinc, and I didn't get this," or "it took this long to do it." I would rather see you use zinc chromate and actual galvanized coupons of the same stuff that's in the plant as opposed to trying to simplify the experiment. And so I think that that's an important factor.

So the question becomes -- do you issue

Rev. 3 now, or do you say, gee, we don't know enough about everything that's important; why don't we learn everything that we can, and then issue some final Reg. Guide? And I guess I come down thinking that what's in the Reg. Guide is not incorrect, even though there are some assumptions that folks can question.

But it's not incorrect. It may be incomplete, but I think the industry knows that, and the staff knows that. So when I ponder whether or not it should be issued or not, I guess I come down on the side that it ought to be, with the expectation that research has to continue, and that there will be a further revision.

And I don't think that you can resolve with certainty whether plants comply with the three or four general design criteria or not until you know a little bit more about these effects. So that would be my opinion.

CHAIRMAN WALLIS: Vic?

MEMBER RANSOM: Well, I guess I'd like to support what Dr. Kress suggested, that there seemed to be many opportunities for risk-informing this sort of thing, and as opposed to an Appendix K conservative-type approach that's being taken.

It also turns out, coming from the west

and all the irrigation ditches that are around and the paper mills and -- as well as sewage plants, I can't believe that you'd want to rule out or be careful not to rule out solutions which include active trash mitigating schemes as well as inactive ones.

I mean, with a system where you can essentially eliminate the problem, I don't know how that factors into a plant. That's another issue.

But, and a lot of those schemes, too, would eliminate I think the chemical aspect of the problem, if it exists. So whatever is put in the Reg. Guide I think should allow the freedom to employ these kinds of things, if they desire them. So --

CHAIRMAN WALLIS: Well, I think I've already said most of the things I would say in summary. I think I agree with what I've heard from my colleagues. It seems to me it's a question of regulatory strategy. We've put out this Guide saying that all of these things need to be considered, and then say wait for industry to respond.

My expectation is that they will not be able to respond very well. And then, the question is up, really, to the NRR folks -- what do you do? What do you do in a situation like this where it does have an effect on safety, where there are -- there's even

-- there's chemical questions which no one really knows the answer to yet, which may turn out to be quite significant in terms of the answers they give.

So it's a very interesting example of a regulatory situation where some kind of wisdom is called for on the part of people administering the regulations. And that's really where I think we need some good answers, because you can put out the Reg. Guide as it is and say, yes, it's not perfect, it's a living document, but at least it gets things going.

And then we can say industry is going to respond. There's also the actions that NRR is taking. It's being played out. I, for one, will be very interested to see how it does play out, and I can't, though, see a sure route to a happy conclusion for everybody.

MEMBER SIEBER: Well, it's sort of interesting -- you know, Section B, which is in every Reg. Guide, is implementation. It sets forth the situations where the Reg. Guide will be used, and it's pretty limited here. I think there's three of them. You know, it's 50.59 things, but it doesn't take the form of some generic communications or a bulletin or anything like that that tells a licensee, "You go out and reexamine your sump." Maybe that comes later.

That's another step in the process.

And so I think industry, unless some issue comes up that forces them into this Reg. Guide, they could sit back until such time as NRR decides -- or the Commissioners decide -- you know, we want everybody to demonstrate compliance. And they could do that at any time, and, in fact, an inspector in the plant could do that. He could ask for the licensee's calculations.

MR. ARCHITZEL: But imposing the Reg. Guide would be a backfit. They would have to go through CRGR, if it's on more than one --

MEMBER SIEBER: That's right. And that's why D is written the way it is, I presume, because the first one talks about new construction, plants that aren't built yet. The second one is application of 50.59 and, you know -- and so I can see the strategy just from the words that were used.

MR. ARCHITZEL: That's 50.59 comment actually comes from 1985 --

MEMBER SIEBER: Yes.

MR. ARCHITZEL: -- where the issue was it wasn't cost beneficial. But as you do 50.59 changes, consider that in terms of when you're placing out insulation. But in point of --

MEMBER SIEBER: It comes with an extra factor.

MR. ARCHITZEL: Right. It's a little different. It's estranged in the Reg. Guide. But the other point is if the committee considers it appropriate to examine -- I mean, Research is going before the CRGR. You could change this into a potential -- it's a lot different. You could do a cost-benefit.

MEMBER SIEBER: Yes.

MR. ARCHITZEL: It could be considered differently before the CRGR.

MEMBER SIEBER: Yes. So, anyway, to me the strategy is sort of obvious as to what it is you're doing. That's okay. You know, that's the way regulation works. That's the way this agency does things, and I don't see anything wrong with it.

CHAIRMAN WALLIS: Okay.

MR. HSIA: Let me just put in a couple of new pieces of information. The meeting with CRGR is August 26th, and so -- and the meeting -- we are coming back to the full committee on September 11th, and we are meeting with industry on September 10th.

So things are going to happen. Decisions will be made and recommendations will be made by a lot of different people. So we will keep -- fully keep your staff informed. Therefore, you will be informed.

And I'm guessing that you will make a decision on this Reg. Guide after the full committee, is that correct?

CHAIRMAN WALLIS: Yes. No decisions are made except by the full committee.

MR. HSIA: Okay. So by that time, we'll wait and see, see whether there are other inputs. Maybe it can make your decision a little easier. But in any case, it's not an easy one. We realize that. And we thank you for giving us the time.

CHAIRMAN WALLIS: Okay. With that, I'd like to close the meeting, and I will do so. We are now adjourned.

(Whereupon, at 12:39 p.m., the proceedings in the foregoing matter were adjourned.)

CERTIFICATE

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

Name of Proceeding: Advisory Committee on Reactor Safeguards Thermal-Hydraulic Phenomena Subcommittee

Docket Number: n/a

Location: Rockville, MD

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

Debra Wilensky

Debra Wilensky
Official Reporter
Neal R. Gross & Co., Inc.

Wednesday, August 20, 2003
Regulatory Guide 1.82, Revision 3 - "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident"

15)	**Introduction**	G. Wallis - ACRS	8:30:8:35 am
16)	**Opening Remarks**	T. Hsia - RES	8:35-8:45 am
17)	**Public comments and resolution**	T.Y. Chang - RES	8:45-9:15 am
18)	**Summary of RG 1.82 / Discussion of accident sequences**	T.Y. Chang - RES / B. Letellier - LANL	9:15-10:15 am
	BREAK		10:15-10:30 am
19)	**Suggestions for alternative solutions**	B. Letellier - LANL	10:30-11:00 am
20)	**Closing Comments**	T.Y. Chang - RES	11:00-11:15 am
21)	**Committee Discussion**	G. Wallis - ACRS	11:15 am-12:00 noon
	ADJORN		NOON

<u>Note</u>:

Presentation time should not exceed 50% of the total time allocated for a specific item.

Number of copies of presentation materials to be provided to the ACRS - 35.

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
MEETING OF THE SUBCOMMITTEE ON
THERMAL-HYDRAULIC PHENOMENA
ROOM T-2B3, 11545 ROCKVILLE PIKE, ROCKVILLE, MD
August 19-20, 2003

ACRS Contact: Ralph Caruso (301) 415-8065
E-mail: rxc@nrc.gov

- PROPOSED SCHEDULE -

Tuesday, August 19, 2003 - Review Standard for Extended Power Uprates

	TOPIC	PRESENTER	TIME
1)	Introduction	G. Wallis, V. Ransom - ACRS	8:30-8:35 am
2)	Opening Remarks	W. Ruland - NRR	8:35-8:50 am
3)	Development of RS-001	M. Shuaibi - NRR	8:50-9:20 am
4)	Containment Review	R. Lobel - NRR	9:20-9:50am
5)	Mechanical Engineering	K. Manoly - NRR	9:50-10:35 am
	BREAK		10:35-10:50 am
6)	Plant Systems	J. Tatum - NRR	10:50-11:20 am
7)	Risk Evaluation,	D. Harrison - NRR	11:20 am-12:00 noon
	LUNCH		Noon-1:00 pm
8)	Material Engineering	T. Sullivan - NRR	1:00-1:30 pm
9)	Reactor Systems	S. Peters, Z. Abdullahi - NRR	1:30-2:15 pm
10)	Human Factors	R. Eckenrode - NRR	2:15-2:45 pm
	** BREAK**		2:45-3:00 pm
11)	Power Ascension/Testing	K. Coyne, R. Pettis - NRR	3:00-3:30 pm
12)	ACRS/Public Comments	M. Shuaibi - NRR	3:30-4:00 pm
13)	Closing	W. Ruland - NRR	4:00-4:15 pm
14)	Committee Discussion	V. Ransom, ACRS	4:15-5:00 pm
	ADJORN		5:00 pm

ECCS Sump Operability Strategies

Bruce Letellier
Design Safety and Risk Analysis Group
Los Alamos National Laboratory

ACRS Thermal Hydraulics Subcommittee
Nuclear Regulatory Commission, Rockville, MD
August 20, 2003

Background for Discussion of "Alternative Solutions"

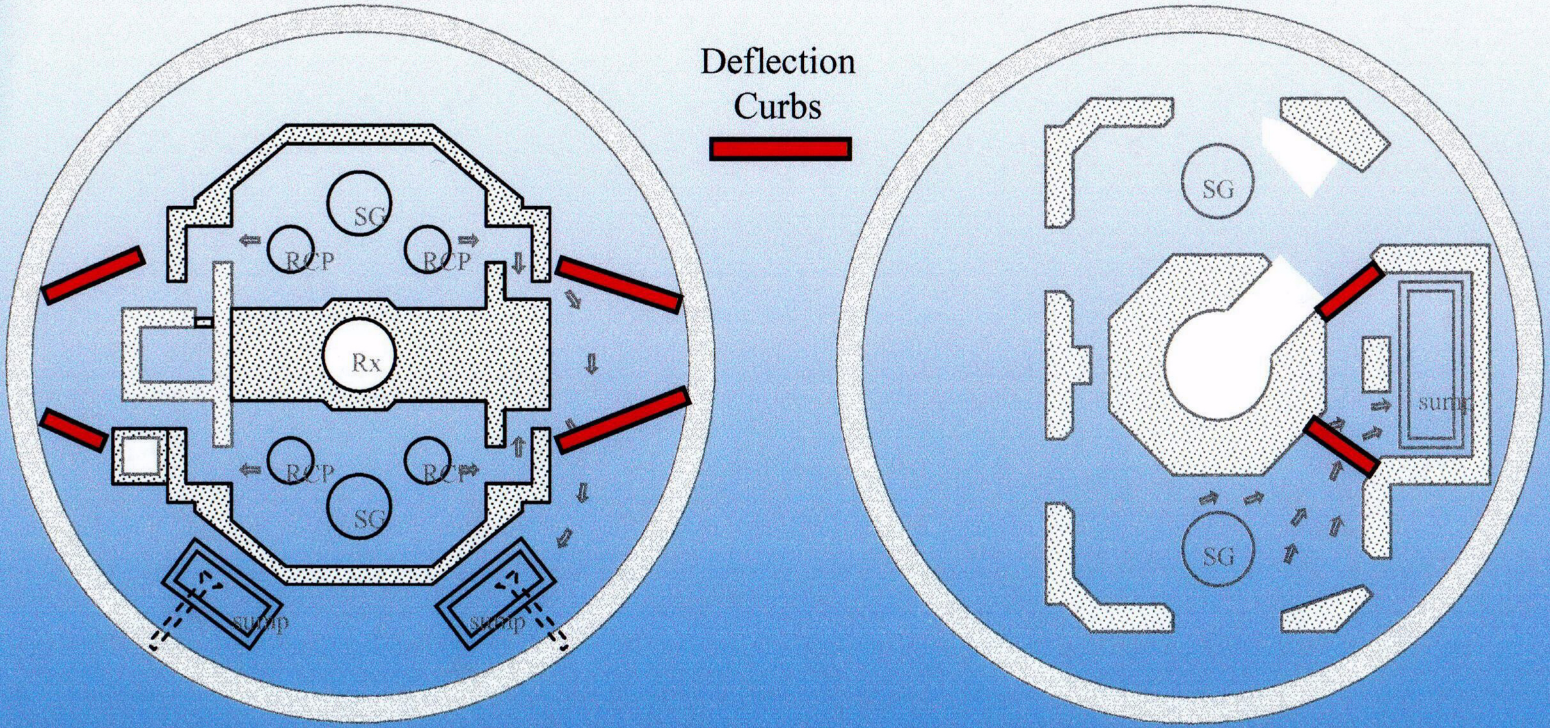
- Although plant specific responses have not been received, there is the perception that many plants will have to mitigate vulnerabilities
- No formal tasking to investigate mitigation/solution methods
- Proposed strategies offered to stimulate discussion. No claim of practicality, effectiveness, or present NRC endorsement
- Topics represent engineering insights gleaned from GSI-191 research and analysis
- Some proposed strategies may require significant research/test/analysis investment to develop and implement

Topics for Discussion

- Debris Diversion During Fill-up
- Sump Screen Design Elements
- Active Debris Removal
- Sacrificial Screen Area
- Integrated Sump Protection Philosophy

Debris Diversion During Fillup

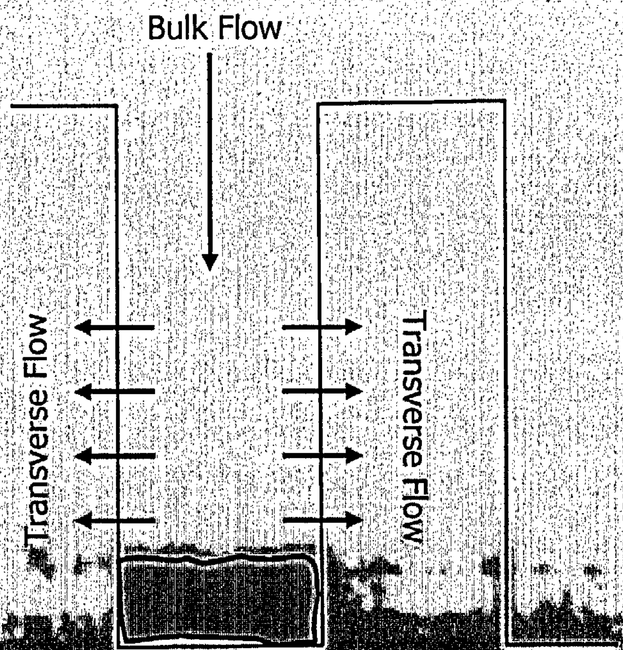
- **Debris on the floor during initial spray water drainage may be subject to additional degradation**
- **Diversion during pool fill up is a good opportunity for long-term capture in quiet pool areas not impacted by spray return**

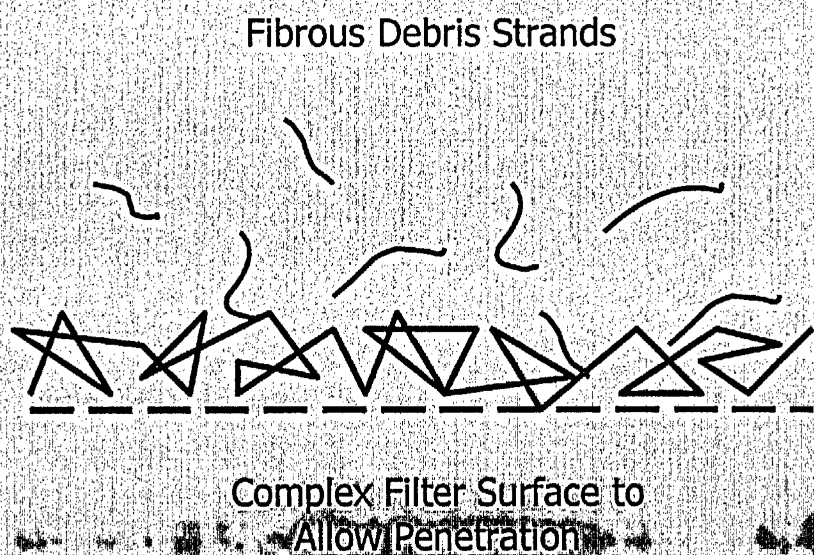


C01

Sump Screen Design Elements

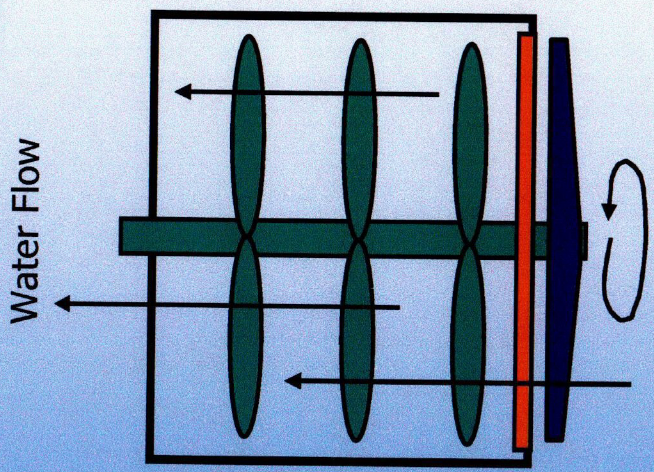
- **Large screen area alone may be insufficient**
  - Transverse flow designs to accommodate large debris volumes
  - Engineered surface to defeat thin-bed formation
    - Crumpled wire mesh or lattice acts as filter medium



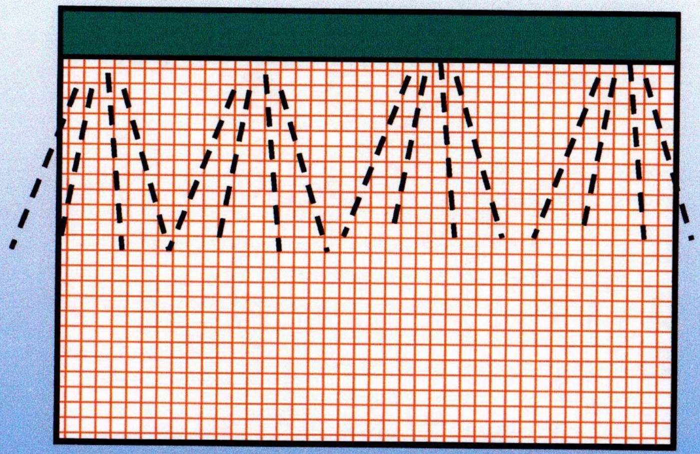


Active Debris Removal

- All concepts should incorporate final debris retention
- Backflush and/or pump cycling
- Continuous or actuated mechanical/hydraulic removal



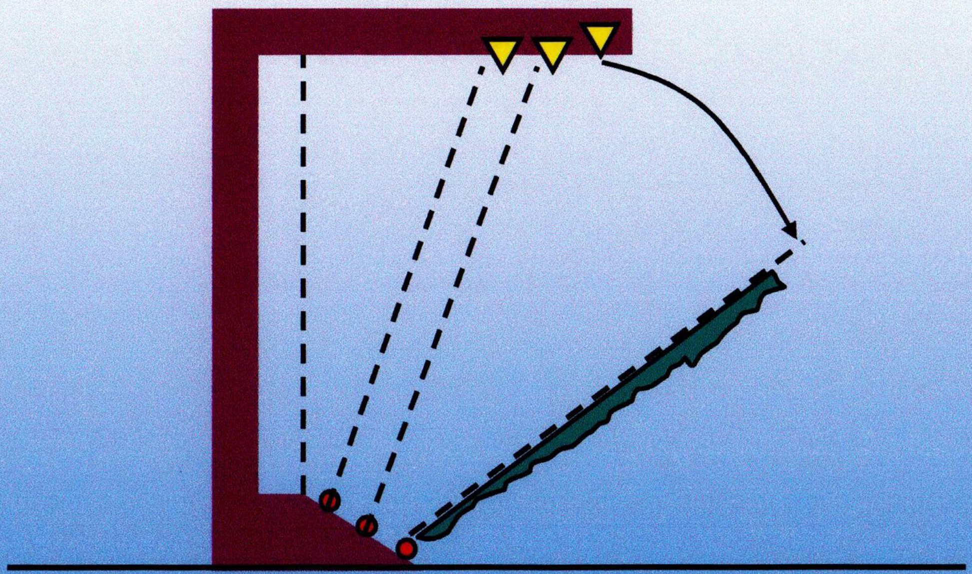
Flow Driven Scraper



Nozzle Curtain to Divert Debris

Sacrificial Screen Areas

- Take advantage of directed flow toward sumps for permanent debris trapping
- Design screens with multiple layers that can be "removed" or "released" when head loss becomes unacceptable
- Hinge points can be simple channels
- Inner screen can be crenulated vertical surface



Sump Protection Philosophy

- **More water in containment**
  - Procedural modifications to delay recirculation
  - Alternative water sources
- **Careful attention to spray return cascades to design quiet pool zones for long-term debris retention**
- **Plant cleanliness (FME programs)**
- **Sump screen maintenance for proper installation**
- **Casing/banding of vulnerable insulation types**
- **Removal/abatement of vulnerable insulation types**
- **Operator awareness/training of mitigation options**
- **Sump flow diagnostics/instrumentation**

United States Nuclear Regulatory Commission

Regulatory Guide 1.82, Rev. 3 "Water Sources for Long-Term Recirculation Cooling Following A LOCA"

Dr. T. Y. Chang
Division of Engineering Technology
Office of Nuclear Regulatory Research
US Nuclear Regulatory Commission

Dr. Bruce Letellier
Probabilistic Risk Analysis Group
Los Alamos National Laboratory

August 20, 2003

United States Nuclear Regulatory Commission

OVERVIEW

- Background
- Reason for Issuing Rev. 3 and Use of RGs
- RG 1.82, Rev. 3 Activities
- Key Revisions in RG 1.82, Rev. 3
- Resolution of Public Comments on DG-1107
- Summary of RG 1.82 / Discussion of Accident Sequences (NRC/LANL)
- RES Future Activities (GSI-191)

Background

- Revision 0 – Issued June 1974
  - ❑NPSH Calculations Based on 50% Blockage of Sump Screen
- Revision 1 – Issued November 1985
  - ❑Guidance Based on USI A-43 Resolution
- Revision 2 – Issued May 1996
  - ❑Revised Guidance for BWRs
  - ❑Requested Licensee to Implement Measures to Ensure ECCS Functions Following LOCA (NRC Bulletin 96-03)
- Revision 3 – Issue September 2003 (Planned)
  - ❑Revised Guidance for PWRs (GSI-191)

Reason for Issuing Rev. 3 and Use of RGs

- Contributes to resolution of GSI-191
- RG 1.82 is revised to enhance the debris blockage evaluation guidance for PWRs and to provide guidance of methods acceptable to the staff.
- Research after issuance of Rev. 2 indicated that Rev. 2 was not comprehensive enough to ensure adequate evaluation of a PWR's susceptibility to the effects of debris blockage of debris interceptors.
- RGs are not substitutes for regulations, and compliance is not required.
- Alternative methods different from those in RGs can be proposed and will be considered by the staff for acceptance.

RG 1.82, Rev. 3 Activities

- Briefed ACRS – 2/03
- Issued DG -1107 For Public Comment – 2/03 to 4/03
- Resolved Public Comments
- Brief ACRS T-H Subcommittee 8/20/03, CRGR 8/26/03, ACRS Full Committee 9/11/03
- Resolve Comments
- Issue RG 1.82, Rev. 3 in 9/03

United States Nuclear Regulatory Commission

Key Revisions In RG 1.82 Rev.3

- Primarily, PWR Sections Revised to Enhance Debris Blockage Evaluation Guidance
  - ❑ Consistent with BWRs Guidance in Rev.2, and,
  - ❑ Insights gained from Research Performed Under GSI -191
- Changes to BWR Sections

  (To be Consistent with PWR Sections in RG 1.82, Rev.3, and Staff's Position in Safety Evaluation on BWROG's Utility Resolution Guidance (URG) for ECCS Suction Strainer Blockage, 1998)
- Includes Guidance Previously Provided in RG 1.1, "Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal System Pumps"

United States Nuclear Regulatory Commission

Resolution of Public Comments on DG-1107

- 89 Comments received
- Comments were from 4 utilities, Westinghouse, NEI and 1 individual
- Comments and concerns raised most frequently
  - ❑ Conformance Issue for current plants (13)
  - ❑ Containment Pressure for Design of ECCS (8)
  - ❑ Screen Mesh Size (4)
  - ❑ Leak-Before-Break for Debris Source (4)
  - ❑ Partially Submerged Screens and Failure Criteria (4)
  - ❑ Basis for 1/8" Thin Bed Value (3)
  - ❑ Adequate Protection from Missiles (3)
  - ❑ Use of CFD and Other Methods for Debris Transport Calculation (2)

Resolution of Public Comments (con.)

- Conformance Issue for Current Plants (13)
  - ❑ **Comments** - How RG will be used for current plants.

    Response - D. Implementation made clear that no backfitting is intended or approved. RG will be used in the evaluation of current licensees' methodologies for long-term recirc cooling capabilities of ECCS and CCS following a LOCA.
  - ❑ **Comments** - Some current plants have different designs as compared to the RG positions, e.g., multiple sumps.

    Response - Section C made clear RG is generic and it may go beyond current designs.
  - ❑ **Comments** - RG appears to favor a particular configuration of screens and trash racks for ECCS sump. More advanced design should be allowed.

    Response - "Conceptual features" have been added to **Figures 1 and 2. C.1.1.1.16** is added to state that it may be desirable to consider advanced strainer designs since they have demonstrated capabilities not provided by simple screen designs.

Resolution of Public Comments (con.)

- Containment Pressure to be Used for the Design of ECC and Containment Heat Removal Systems (8)
  - **Comment – C.1.3.1.1** states that ECC and containment heat removal systems should be designed so that sufficient available NPSH is provided to the system pumps, assuming no increase in containment pressure from that present prior to the postulated LOCAs. This is not consistent with the licensing basis for subatmospheric containment plants, which can operate as low as 9 psia air partial pressure.

    Response – C.1.3.1.1 has been modified to state that ECC and containment heat removal systems should be designed so that sufficient available NPSH is provided to the system pumps, assuming the maximum expected temperature of pumped fluid and no increase in containment pressure from that present prior to the postulated LOCA. For subatmospheric containments, this guidance should apply after the injection phase has terminated. Prior to termination of the injection phase, NPSH analyses should include conservative predictions of the containment atmospheric pressure and sump water temperature as a function of time.

United States Nuclear Regulatory Commission

Resolution of Public Comments (con.)

- Screen Mesh Size (4)
  - **Comments -**

    1. RG states that the mesh size should be smaller than the minimum restrictions found in systems served by ECC sumps. This will lead to much higher pressure drops than current screens and may need screen areas too large to be practical.

    2. Long thin debris slivers passing axially through the sump screen and the reorienting and clogging the flow restrictions downstream should be considered.

    Response -

    1. **C.1.1.1.12** is modified to state the size of sump screen opening should be determined considering the flow restrictions of systems served by the ECCS sump, and if mesh size is impractical to be fine enough to filter out particles of debris that may cause damage to ECCS pump seals or bearings, then it is expected that modifications would be made to ECCS pumps or ECCS pumps would be procured that can operate long term under the probable conditions.

    2. Agree with comment 2, and a sentence is added to C.1.1.1.12.

Resolution of Public Comments (con.)

- Leak-Before-Break for Debris Source (4)
  - **Comment** – RG position in **C.1.3.2** requiring application of large breaks at essentially all locations in the RCS for debris generation based on requirement of 10 CFR 50.46 (the most severe postulated LOCAs should be calculated) is inconsistent with the leak-before-break (LBB) position of GDC 4 of 10 CRF 50, Appendix A.

    Response – No change. Staff position was documented in a letter to WOG (6/9/00). Staff position is that LBB is not applicable to LOCA-generated debris. NRC however is in receipt of an NEI request to consider alternatives to a DEGB for debris generation, and this is a policy issue that may result in changes to break size used for debris generation.

Resolution of Public Comments (con.)

- Partially Submerged Screens and Failure Criteria (4)
  - **Comment** – RG states that credit should only be given to the portion of the sump screen that is expected to be submerged at the beginning of recirculation. Allowance should be provided for circumstances in which the level of submergence changes substantially following the beginning of recirculation.
  - **Response** – **C.1.3.4.4** has been modified to state that for partially submerged sumps, credit should only be given to the portion of the sump screen that is expected to be submerged as a function of time. Pump failure should be assumed when the head loss across the sump screen is greater than ½ of the submerged screen height or the NPSH margin.

Resolution of Public Comments (con.)

- Basis for 1/8" Thin Bed Value (3)
  - **Comment** – This 1/8" thin bed value does not seem to have a supporting technical basis.

    Response – **C.1.3.2.3** has been modified to reference NUREG/CR – 6224 as the source for the supporting technical basis.

Resolution of Public Comments (con.)

- Adequate Protection from Missiles (3)
  - **Comment** – RG states that the trash racks and sump screens should be capable of withstanding the loads imposed by expanding jets, missiles, the accumulation of debris, and pressure differentials caused by post-LOCA blockage under design-basis flow conditions. Will NRC give consideration to the existence of torturous paths that would prevent direct missile impingement on ECCS suction screens for some PWRs?

    Response – **C.1.1.1.6** adds a statement that credit for any protection to trash racks and sump screen offered by surrounding structures should be justified.

Resolution of Public Comments (con.)

- Use of CFD and Other Methods for Debris Transport Calculation (2)
  - **Comment** – Computational Fluid Dynamics (CFD) simulation method is mentioned by RG as an acceptable analytical approach to predict debris transport within the sump pool. Channel flow method has been used successfully to demonstrate debris transport in both the nuclear industry and other industries, and should be identified as acceptable.

    Response – C.1.3.3.4 has been modified to state that alternative methods are acceptable, provided they are supported by adequate validation of analytical techniques using experimental data to ensure estimates are conservative.

Resolution of Public Comments (con.)

- Clarification on Seismic Event Position (1)
  - **Comment – C.1.1.1.8** of RG states that the debris interceptors should be designed to withstand the vibratory motion of seismic events without loss of structural integrity. This section should clarify the possible seismic event concurrent with a LOCA is typically not postulated, however during the 30 days mission time following a LOCA, a seismic event may be possible. This event would create sloshing and hydrodynamic loads on the strainer assembly.

    Response – C.1.1.1.8 has been modified to state that the debris interceptors should be designed to withstand the inertial and hydrodynamic effects that are due to vibratory motion of a safe shutdown earthquake (SSE) following a LOCA without loss of structural integrity.

Resolution of Public Comments (con.)

- Basis for Size of ZOI (1)
  - **Comment** – Does NRC intend to scale the size of ZOI for debris generation based on the operating pressure or design pressure for a particular system, or based on the specific total energy of the process fluid for that system?

    Response – **1.3.2.2** has been modified to state that the size of ZOI should be consistent with the debris source (insulation, fire barrier material, etc.) damage pressures, i,e., the ZOI should extend until the jet pressures decrease below the experimentally determined damage pressures appropriate for the debris source.

Resolution of Public Comments (con.)

- Samples of Other Comments
  - **Comment** – NPSH definition is not clear

    Response – Def. from ANSI/HI 1.1-1.5-1994, "ANS for Centrifugal Pumps for Nomenclature, Definitions, Applications and Operation" was quoted in Section B, PWRs, and Appendix A, "Guidelines for Review of Water Sources for Emergency Core Cooling."
  - **Comment** – C.1.3.2.6 of RG requires consideration of debris generated by chemical reactions in the pool. Does NRC intend to publish results of study or cite available references?

    Response – The staff acknowledges that there are no NRC published references pertinent to consideration of these chemical reactions that can be cited in the RG.
  - **Comment** – In a letter to the staff after the 2/03 meeting, ACRS raised the concern that "The staff should evaluate the possibility that strainers may prove to be so susceptible to debris blockage that alternative solutions may be required to ensure long-term cooling. The staff should invite public comments on this matter."

    Response – The staff has added C.1.1.4 to address the possible need for alternative solutions and has specifically invited public comments on the matter in the Federal Register Notice. No comment on this matter was received.

Summary of RG 1.82 / Discussion Of Accident Sequences

- Debris Sources and Generation
- Debris Transport
  - ❑Airborne Debris Transport
  - ❑Washdown Debris Transport
  - ❑Sump Pool Debris Transport
- Sump Pool Debris Transport
- Sump-Screen Head Loss

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Debris Sources and Generation (C.1.3.2)

- For debris generation calculations, a number of LOCAs of different sizes and locations should be postulated to provide assurance that the most severe postulated LOCAs are calculated.
- Level of severity corresponding to postulated break should be based on potential head loss incurred across the sump screen.
- "Zone of Influence" (ZOI) can be used to estimate amount of debris generated by a postulated LOCA.
- In some designs, postulation of break locations in main steam (MS) and main feedwater lines (MF) may be needed to determine the most limiting conditions for sump operation.
- All potential debris sources should be considered within the ZOI.

Debris Sources and Generation (Con.)

- As a minimum, break locations should be at:
  - ❑RCS (and MS, MF if needed from licensing basis) with the largest amount of potential debris within the postulated ZOI
  - ❑Large breaks with 2 or more different types of debris within the expected ZOI
  - ❑Breaks in areas with the most direct path to sump
  - ❑Medium and large breaks with the largest potential particulate to insulation ratio by weight
  - ❑Breaks that generate fibrous debris that could create the "thin-bed effect" at sump screen

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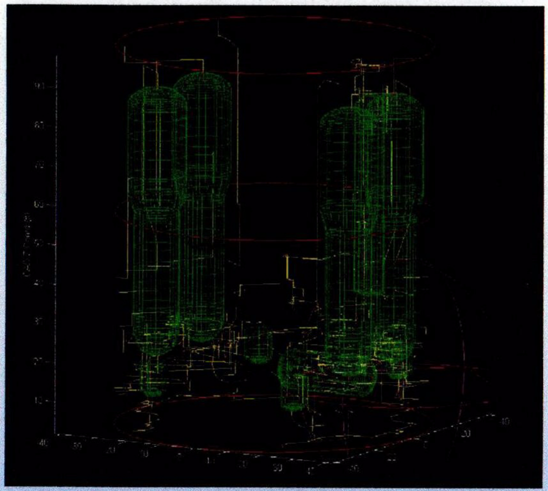
Debris Generation – Break Location

- Spatial model/drawings of plant piping essential unless 100% damage of insulation inventory is assumed
- Breaks in all systems that lead to recirculation requirements
- Break severity defined in terms of potential head loss implies "break-to-blockage" transport anal.



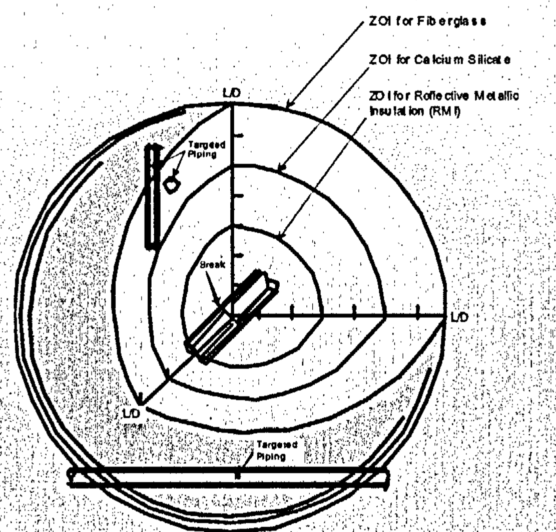
- Acceptable Methods:
  - BWR precedent for assumed 100% damage of insulation inventory
  - Precedent for point-by-point break analysis set by NUREG/CR-6224, BWR resolution audits, Volunteer Plant Study, existing commercial analysis tools
  - Spatial model details may be simplified by considering grouping of insulation type, location, etc.

Debris Source References

- NUREG/CR-2403 "Survey of Insulation Used in Nuclear Power Plants and the Potential for Debris Generation," 1981.
- NEI-Conducted Plant Survey
  - NUREG/CR-6762, Vol. 2, "GSI-191 Technical Assessment: Summary and Analysis of U.S. Pressurized Water Reactor Industry Survey Responses and Responses to GL 97-04," 2001.
- Section 2 of Knowledge Base Report describes sources of debris including past history of debris removed from plants.
  - NUREG/CR-6808, "Knowledge Base for the Effect of Debris on Pressurized Water Reactor Emergency Core Cooling Sump Performance," 2003.

Debris Generation – Zone of Influence

- Shock wave and jet pressures should be the basis for estimating the amount and size distribution of debris
- Jet pressures should be determined by analysis or experiment
- Material-specific damage pressures should be determined by experiment with default total damage. Data base *not* all inclusive



- Acceptable Methods:

Pressure-equivalent spherical damage zones without truncation

- NUREG 6224, BWROG URG and NRC's Staff Evaluation of URG

Pressure-conserved deflected damage zones with analysis or experiment

- Original calculation of jet pressure contour volumes using ANSI/ANS and EPRI jet models

Debris Generation References

- A three-zone spherical destruction model was introduced before 1985.
  - NUREG-0897, "Containment Emergency Sump Performance," Technical Findings Related to Unresolved Safety Issue A-43, 1985.
- The three-zone spherical model was adapted for the NUREG/CR-6224 study.
  - NUREG/CR-6224, "Parametric Study of the Potential for BWR ECCS Strainer Blockage Due to LOCA Generated Debris," 1995.
- BWROG URG
  - NEDO-32686, Rev. 0, "Utility Resolution Guidance for ECCS Suction Strainer Blockage," 1996.
  - NRC-SER-URG, "Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Bulletin 96-03 Boiling Water Reactor Owners Group Topical Report NEDO-32686, 'Utility Resolution Guidance for ECCS Suction Strainer Blockage,'" Docket No. PROJ0691, 1998.
- The parametric evaluation employed a spherical ZOI model.
  - NUREG/CR-6762, Vol.1, "GSI-191 Technical Assessment: Parametric Evaluations for Pressurized Water Reactor Recirculation Sump Performance," 2002.
  - NUREG/CR-6762, Vol. 3, "GSI-191 Technical Assessment: Development of Debris-Generation Quantities in Support of the Parametric Evaluation," 2001.
- Methodologies summarized in NUREG/CR-6808.

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Debris Transport (C.1.3.3)

- Debris transport analyses should consider each type of insulation and debris size.
- 3 types of debris transport should be considered for debris sources to the sump screen: airborne, washdown, and sump pool debris transport.
- In lieu of performing analyses for airborne, washdown and sump pool debris transport, it could be assumed that all debris will be transported to the sump screen.
- If all drains leading to the sump could become blocked or inventory holdup could happen with debris on screen, the consequence could be worse than 100% transport, and should be assessed.

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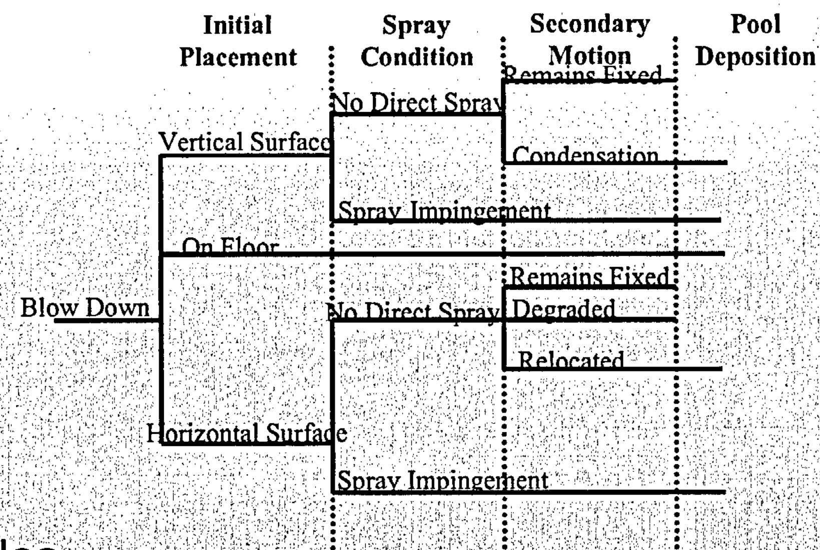
Transport – Blowdown/Washdown

- Debris initially dispersed by depressurization flow with inertial impaction and eventual settling
- Spray impingement and drainage
  - Scavenge remaining airborne
  - Direct wash of structures/equip
  - Entrainment/Trapping during drainage (BWR data on gratings)
  - Erosion from direct spray impingement and drainage cascades



- Acceptable Methods:
  - No integrated numerical models specific for debris transport
  - Debris disposition charts with fractions based on data/judgment as peer reviewed by BWR Phenomena Identification and Ranking Table (PIRT)

Airborne/Washdown Debris Transport Refs

- BWR Drywell Debris Transport Study provided transport methodology with BWR results adaptable to PWR (the BWR PIRT panel study was reconvened to peer review the methodology and results).
  - NUREG/CR-6369, Volume 1, "Drywell Debris Transport Study," U.S. Nuclear Regulatory Commission, 1999.
  - NUREG/CR-6369, Volume 2, "Drywell Debris Transport Study: Experimental Work," 1999.
  - NUREG/CR-6369, Volume 3, "Drywell Debris Transport Study: Computational Work," 1999.
- BWROG URG provided BWR Guidance that could support PWR resolution.
  - NEDO-32686, Rev. 0, "Utility Resolution Guidance for ECCS Suction Strainer Blockage," 1996.
  - NRC-SER-URG, "Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Bulletin 96-03 Boiling Water Reactor Owners Group Topical Report NEDO-32686, 'Utility Resolution Guidance for ECCS Suction Strainer Blockage,'" Docket No. PROJ0691, 1998.
- Methodologies summarized in NUREG/CR-6808 knowledge base.

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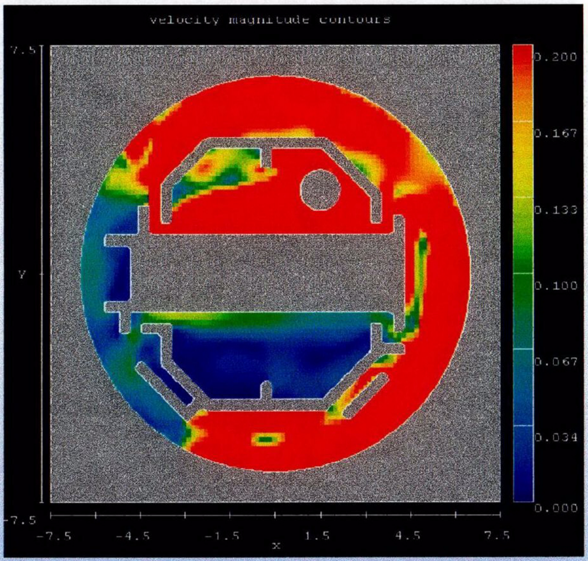
Sump Pool Debris Transport (C.1.3.3)

- Containment sump pool debris transport should include: (1) debris transport during pool fill-up phase and recirculation phase; (2) the turbulence in the pool caused by the flow of water, water entering the pool from break overflow, and containment spray drainage; and (3) buoyancy of the debris.
- Debris should be considered in the transport analyses are: (1) debris that would float along the pool surface; (2) debris that would remain suspended due to pool turbulence; and (3) debris that readily settles to the pool floor.
- CFD simulation in combination with the experimental debris transport data is an acceptable approach to predict debris transport within the sump pool. Alternative methods are acceptable provided they are supported by adequate validation of analytical techniques using experimental data to insure that the debris transport estimates are conservative with respect to the quantities and types of debris transported to the sump screen.

Transport – Sump Pool

- Debris washed down in spray drainage vulnerable to degradation and transport (integrated tank test examples)
- Debris on floors sequestered during fill up from spray drainage generally not vulnerable to degradation or transport
- Steady-state velocity patterns with break flow and spray drainage identify stable zones for long-term debris retention
- Linear flume tests characterized incipient flow and settling velocities for major debris types



- Computational Fluid Dynamics, Sheet-flow approximations of fillup, and Open-Channel Network Flow models of steady-state velocity patterns provide a basis for informed decisions regarding transport fate
- Uncertainties in location and timing of debris entering pool limit the need for a high fidelity model of debris transport

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Transport – Sump Pool

- Acceptable methods:
  - CFD or simplified sheet-flow analysis of fill up patterns
  - CFD or network flow analysis of steady-state flow patterns
  - No integrated transport models specific for sump-pool debris transport
  - Transport logic charts based on conservative judgment and data
    - Incipient flow velocities of debris and area fractions above threshold
  - Peer reviewed articles on CFD modeling of scaled tank tests
  - Logic chart to combine calculated flow velocity with test data.

Sump Pool Debris Transport References

- **During the resolution of USI A-43, sump pool analyses were performed and a few small scale tests were conducted.**
  - NUREG-0897, "Containment Emergency Sump Performance," Technical Findings Related to Unresolved Safety Issue A-43, 1985.
- **Some BWR resolution data applicable to PWR (e.g., debris settling data).**
  - NUREG/CR-6224, "Parametric Study of the Potential for BWR ECCS Strainer Blockage Due to LOCA Generated Debris," 1995.
  - NUREG/CR-6368, "Experimental Investigation of Sedimentation of LOCA-Generated Fibrous Debris and Sludge in BWR Suppression Pools," 1995.
- **NRC has conducted small-scale tests to provide data to support debris transport models.**
  - NUREG/CR-6882, "GSI-191: Separate-Effects Characterization of Debris Transport in Water," 2002.
  - NUREG/CR-6773, "GSI-191: Integrated Debris Transport Tests In Water Using Simulated Containment Floor Geometries," 2002.
- **NRC has evaluated important processes and phenomena.**
  - LA-UR-99-3371, "PWR Debris Transport in Dry Ambient Containments—Phenomena Identification and Ranking Tables (PIRT)," 1999.
  - LA-UR-99-5111, "PWR Debris Transport in Ice Condenser Containments - Phenomena Identification and Ranking Tables (PIRT)," 1999.
  - Testing as documented in NUREG/CR-6882 and NUREG/CR-6773
  - Phenomena summarized in NUREG/CR-6808 knowledge base
- **Peer reviewed Nuclear Technology articles**
  - Maji, et. al., "LOCA-Generated Debris and Their Transport Characteristics," vol 139, Aug 2002.
  - Maji, et. al., "Transport Fractions of LOCA-Generated Debris in Scaled Containment Geometries," (forthcoming)

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Sump-Screen Head Loss (C.1.3.4)

- For fully submerged sump screens, NPSH available to ECC pumps should be determined using the conditions specified in the plant's licensing basis.
- For partially submerged sumps, Appendix A of this guide states that NPSH margin may not be the only failure criterion. In this case, credit should only be given to the portion of sump screen that is expected to be submerged as a function of time. Pump failure should be assumed to occur when the head loss across the sump screen is greater than ½ of the submerged screen height or the NPSH margin.
- Estimates of head loss caused by debris blockage should be developed from empirical data based on the sump screen design, postulated combination of debris, and its approach velocity. The thin-bed effect on head loss should be considered.

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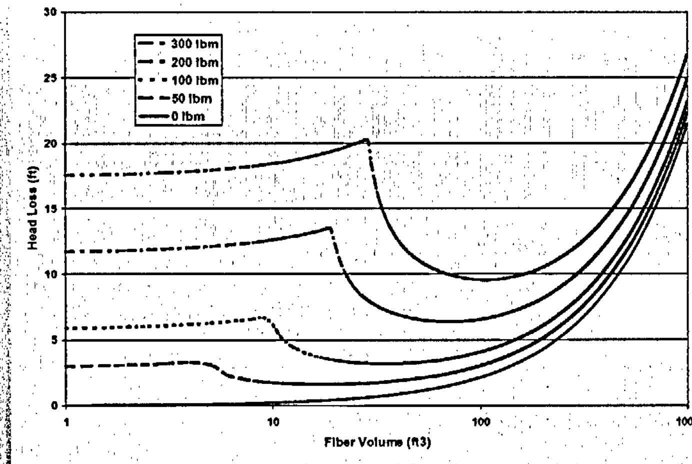
Sump-Screen Head-Loss

- UNM testing confirmed that 6224 head-loss correlation is robust for vertical screens and square mesh for specific debris types
  - Not applicable for high loadings of Cal-Sil or chemical precipitants
- Tests and reports provide an example of analytical technique. Material testing *not* all inclusive
- Correlation implemented in BLOCKAGE PC-utility
- ½ submerged screen depth failure criterion for partially submerged screens unique to PWR

NUREG 6224 Head Loss Analysis



$$\frac{\Delta P}{\Delta L} = \alpha(\varepsilon)\mu U + \beta(\varepsilon)\rho U^2$$

Los Alamos

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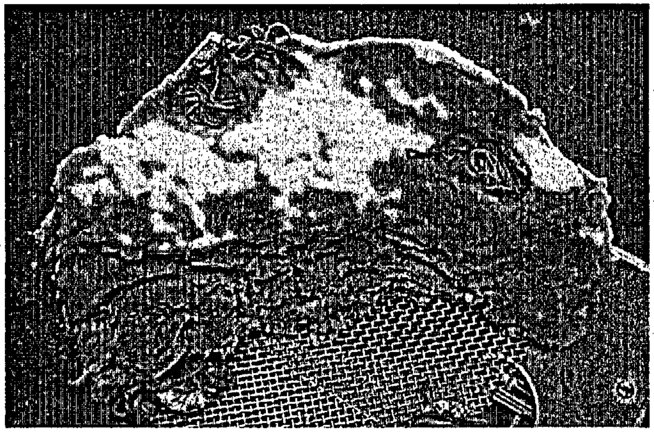
Sump-Screen Head-Loss

- Acceptable Methods:
  - Application of the 6224 correlation *with* appropriate material properties
    - BLOCKAGE or similar implementation
  - Validation of alternative correlations through comparable test procedures
  - Performance tests of screen designs comparable to BWR resolution



Cal Sil + Fiber Debris Bed

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Sump Screen Head-Loss References

- BWR Resolution Research
  - NUREG/CR-6224 head loss correlation
    - NUREG/CR-6224, "Parametric Study of the Potential for BWR ECCS Strainer Blockage Due to LOCA Generated Debris," 1995.
    - NUREG/CR-6367, "Experimental Study of Head Loss and Filtration for LOCA Debris," 1995.
  - BWROG Research
    - URG
    - SER-URG
- NRC PWR Research
  - Calcium Silicate head loss report (forthcoming)
- Head loss testing and analyses summarized in NUREG/CR-6808 knowledge base

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RES Future Activities (GSI–191)

- Near Term (before 10/03)
  - ❑ Cal-Sil Head Loss Test Report
  - ❑ Chemical Test Report
- Long Term (up to 9/04)
  - ❑ Debris Sample Characterization for PWRs
  - ❑ Additional Head Loss Tests
  - ❑ HPSI Throttle Valve Clogging Issue
  - ❑ International Workshop, Feb/March 2004, Albuquerque, NM
- All RES activities scheduled to be completed by end of FY 04