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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

March 19, 2008

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARD

(ACRS)

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SUBCOMMITTEE ON THERMAL HYDRAULIC PHENOMENA

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WEDNESDAY

MARCH 19, 2008

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T3B45, 11545 Rockville Pike, at 8:30 a.m., Sanjoy Banerjee, Chairman, presiding.

COMMITTEE MEMBERS:

SANJOY BANERJEE, Chairman

SAID ABDEL-KHALIK, Member

DENNIS BLEY, Member

MICHAEL CORRADINI, Member

OTTO MAYNARD, Member

NRC STAFF PRESENT:

DAVID BESSETTE

MICHAEL SCOTT

PAUL KLEIN

MATT YODER

RALPH LANDRY

BILL RULAND

STEVE SMITH

ALSO PRESENT:

MO DINGLER

TIM ANDREYCHEK

ART BYERS

GORDON WISSINGER

BOB LITMAN

TABLE OF CONTENTS

P R O C E E D I N G S

(8:34 a.m.)

CHAIRMAN BANERJEE: Without a gavel, I think I have to just call the meeting to order. So the meeting will now come to order, please.

This is a meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Thermal Hydraulic Phenomena.

I am Sanjoy Banerjee, Chairman of the Subcommittee. Members in attendance are Said Abdel-Khalik, Dennis Bley, Mike Corradini, Otto Maynard, and I don't see John Stetkar, but I guess he will be coming.

I would also like to welcome ACRS consultants, and of course, old time ACRS members, former Chairman of the ACRS, in fact, Tom Kress, and Graham Wallis.

David Bessette, who is absent, is the designated federal official for this meeting.

The purpose of today's meeting is to discuss the Pressurized Water Reactor Owners Group report, "Evaluation of Long-term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid," known as WCAP-16793-NP, Revision 0, and the staff's safety evaluation.

The Subcommittee will gather information, analyze relevant issues, and facts, and formulate proposed positions and actions as appropriate for deliberation by the full Committee.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register. We have received no written comments or requests for time to make oral statements from members of the public regarding today's meeting.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register notice. We request that participants in this meeting use one of the available microphones, and please speak directly into the microphones, especially members and consultants, because this is not a microphone that picks up as easily as in the ACRS room.

Okay. So we request that participants in this meeting use of the available microphones when addressing the Subcommittee. The speakers should first identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

With that, I'd like to turn the meeting over to Mike Scott of NRR, who will update us on GSI-

191 status and future activities.

I understand that there will be another meeting, Mike, later this year where you will spend sort of a day bringing everything up to date, right?

MR. SCOTT: At least a day.

CHAIRMAN BANERJEE: Okay. At least a day. Okay. So this is going to be a short updated, right?

MR. SCOTT: Yes. Good morning, everybody. My name, as Dr. Banerjee said, I'm Michael Scott. I am the NRR Branch Chief responsible overall for the resolution of Generic Safety Issue 191.

I'm pleased to have the opportunity to update you all on the status of the issue. If you were here about ten months ago when we last spoke to the Subcommittee, and I know a number of you are new and were not here for that, but in any event, we talked about where we were going at the time, and we anticipated that when we'd come into you about this time in 2008 we'd be here to tell you that we're in the final throes of wrapping it up; that the inputs are done, the testing is done and so on; and we're just reviewing it to allow the staff to close it.

And that is an approximation of where the status is now, but it's not as clean and as complete as we would like it to be at this point for reasons that I will discuss with you as part of this presentation.

I'll also talk about what we plan to bring to you. As Dr. Banerjee reported, we're planning to come back probably in the summer, and I'll talk to you this morning in brief about what we plan to say to you then.

So this is just a status presentation and intended to bring you up to date on where we stand with the overall issue, and then the rest of the day, of course, we'll focus on the topical report that Dr. Banerjee mentioned.

For those less familiar with it, and I'll go over this quite quickly, Generic Safety Issue 191 is PWR emergency core cooling and containment spray system performance in recirculation mode, given the presence of debris after a high energy line break. The primary regulatory vehicle for resolution of GSI-191 is Generic Letter 2004-02, which requested licensees by the end of '07 to have determined what their plant specific debris generation and transport situation is and to have made any necessary modifications to allow them to show compliance with the applicable regulations, the primary one of which is 10 CFR 5045(b)(5), which refers to long-term cooling for the core.

As I mentioned, the objective was to be done with this by the end of 2007, and there is yet work to be done, which I will talk about.

Current status: essentially all of them, all of the licensees with PWRs have installed much larger sump strainers, and when I say much larger, I'm talking of one to two orders of magnitude. A typical strainer before was about 80 square feet. There was, of course, a sizable variation in that, but that's a good, round number, and now a typical strainer size is about 2,000 square feet, and it goes anywhere from 1,000 to I believe the largest one is 6,000 square feet of surface area.

And if you wrap your brain around that, that's taking up a lot of space in containment for these strainers. So the good news is that they have installed these, either they have installed them since Generic Letter 04-02 or a couple of plants already had larger strainers before.

DR. WALLIS: May I ask you, Mike, has any plant yet demonstrated compliance?

MR. SCOTT: I would put it this way, and I was going to talk about that, but several plants believe they are done and have sent us a generic letter submittal that says that. We are just starting to review those. So we have not concluded that anyone is done. We're still working on it.

As the second bullet says here, we believe that the risks to strainer clogging has been reduced significantly from what the risk was in 2004. However, significant uncertainties regarding debris generation, transport and behavior still exist, and this affects the testing that the plants have been doing and the testing that we talked to you about and that several licensees talked to you about last May.

We have concluded that plants can continue to operate safely while we resolve the remaining issues here for the same reasons that were stated in Generic Letter 04-02 regrading the likelihood of the initiating event, the number of compensatory measures that the plants have taken, and other mitigating factors for this.

Integrated head loss testing, which is the method that licensees have chosen to use to address Generic Letter 04-02, is ongoing, and this is what we told you in May we thought would be done, essentially done, by the end of 2007. It has not played out that way for reasons that I will explain.

What we are doing now, what we have been doing and actually we were doing when we talked to you in May of last year was reviewing and commenting on protocols, and we anticipated that we would be wrapping that up, say, in mid-2007, and then the licensees would be doing the testing reflecting our comments towards the end of 2007.

And that testing has been going on, but it has taken a substantial amount of time for the licensees and the vendors that are conducting testing on their behalf to resolve the staff's comments on the testing, and unsurprisingly, when you go and you do testing, you observe and find new information that causes you to reconsider what you thought the facts were before, and that has driven changes in what the staff has viewed as an acceptable test protocol, and so that has further delayed the testing.

So there's a combination of factors that have come together to result in some of the testing that's still going on now.

DR. WALLIS: So one could say, Mike, that some of the testing is research because it discovers new things. It's not just routine testing.

MR. SCOTT: It is not routine testing. The objective is to find a conservative protocol, but hopefully from the licensee's perspective, not an overly conservative protocol. And so they run tests, and they see how the result goes, and the staff observes the tests and has comments, and so you end up potentially with more than one test.

CHAIRMAN BANERJEE: Is there information coming out of these tests which potentially can affect what we -- oh, sorry.

Is there information coming out of these tests that's sort of like how much is passing downstream that can potentially affect today's discussions long-term effects?

MR. SCOTT: I'm not aware of information coming out from head loss testing that is affecting that. Of course, each licensee will end up having to determine what their downstream debris loading is. You will hear today that there are substantial margins available associated with this issue. So I'm not aware that the current testing uncertainties or issues that are going on affect this particular issue.

What they have more impact on is the licensee being able to say, "I have done a conservative test, and my head loss is acceptable, and therefore, I am ready to close this issue."

DR. WALLIS: I would think the trouble would come if you look at the results of different tests for different licensees, which have conflicting conclusions about the phenomena themselves. I would think you might get into that kind of a bind, and then you'd have to figure out what to do.

MR. SCOTT: That could happen. What we are seeing, and I'll talk about this in this presentation, is significant dependence of the result on assumptions such as order of arrival and debris mix and so on. And we knew that that was the case to some extent, but we have observed some significant differences, and that's relatively new information.

Go ahead.

MR. KLEIN: Paul Klein from NRR.

I just wanted to add a clarifying comment to your previous question, Dr. Banerjee. As part of the integrated head loss testing that typically is downstream bypass testing as part of that test scheme and that information is used to inform some of the assumptions which are made with respect to what might transport to the vessel.

CHAIRMAN BANERJEE: Thanks. This must depend on order of arrival and things like that, right?

MR. SCOTT: Order of arrival has an impact clearly on the test results, and that is one of the very difficult things to assess. What is the order of arrival? It can vary depending on where the break is and the magnitude of the break and so on. All of those things are considerations that make the test challenge.

DR. WALLIS: How do you put the debris in? That's the tipping of the bucket and whether you shake it.

CHAIRMAN BANERJEE: Graham, closer to the mic?

DR. WALLIS: How closer can I get?

CHAIRMAN BANERJEE: Pull the mic towards you.

DR. WALLIS: Direction that matters? Okay. Thank you.

CHAIRMAN BANERJEE: Go ahead. Did you get the question?

MR. SCOTT: I think he was making a statement.

CHAIRMAN BANERJEE: Oh. Repeat the statement.

DR. WALLIS: Well, you were talking about order of arrival, and this reminded me of a discussion we had about how you put the debris in.

MR. SCOTT: Yes.

DR. WALLIS: How you stir it up and whether you have a bucket and you put it all in one big shot or whether you dribble it in and all of those things can make a difference.

MR. SCOTT: Yes, and when the staff has observed testing at various vendor facilities, we have had concerns with that along the same lines you're talking about.

Moving on to slide four --

MEMBER CORRADINI: You're going to go through this later, but if I could just make sure I understand. So we're going to talk about testing, given some sort of debris morphology. Somewhere in this you're going to explain how the debris morphology you decided is the right debris morphology given the actinides.

MR. SCOTT: A couple of things I would quality in response to that. One is that we don't plan to discuss testing in detail today. That's not the subject of the meeting. I'm going to update you on a few issues that we have observed just for you to bear in mind when we come back to you in the summer.

Clearly, all of those factors such as you cite are part of the look that we're taking at the testing protocol. So I may not give you a real satisfying answer this morning, but we will come back to you with more information this summer.

Dr. Banerjee had actually suggested that we talk to you about all of this testing today or tomorrow, and I basically said we weren't ready for the reason I'm going to explain to you. The testing is still changing somewhat and new information comes out, and so it's just not to the point to really talk about in detail today.

MEMBER CORRADINI: So maybe at a later date at least you can explain to me the game plan as to how the licensees and the NRR are thinking through the initial conditions that you have to worry about relative to what the debris looks like that you have to worry about. I understand that once you've got that now you're trying to figure out how to stop it appropriately. I'm trying to figure out what's the initial condition that you're trying to stop.

MR. SCOTT: I understand, and that's not a two-minute conversation, and frankly, we're not prepared to make a detailed presentation on it today. There are documents that I can point you to, and we will certainly discuss it this summer. I'd like to accommodate you, but it's just not part of the detailed discussion today.

Slide four, audits. We mentioned to you we were going to do audits. We've done nine of them, and we're complete on the full scope audits. The audits were intended to evaluate in some detail the licensee's corrective actions. It involved sending a multi-person team to the sites for a weak.

The results you can see here summarized on the slides. We found in general that the licensees are following staff approved guidance for evaluating the debris issues, such as what you talked about a minute ago, the morphology. We found in general that they were following the guidance.

Perhaps unsurprisingly, sometimes the conclusions and assumptions were not always well supported, in which case that licensee might have gotten an open item to provide initial documentation.

And in two areas we found in general that the audits did not yield useful information, those being chemical effects and downstream effects. The reason for that, downstream effects, in particular in vessel downstream effect, is because the licensees had not performed those analyses. They were waiting either on WCAP 16530, which Paul Klein will briefly discuss today. That's the chemical effects topical report, or they were waiting on the WCAP 16793 that we're going to talk about today before they did these analyses.

So we went to the sites and they hadn't done the analyses, and so we did not obtain useful information. Therefore, we have decided to conduct several additional limited scope audits in 2008 to obtain additional assurance in those areas that the licensees have done an adequate job. We'll be doing those this spring hopefully.

I mention to you that we anticipated being done by 12/31/07 or at least the licensees being done by 12/31/07. They did not. Most of them, I should say, did not report completion by 12/31/07. A few did. I would say four or five plants, maybe eight units reported they were complete. The rest needed additional time to conduct one or more activities.

DR. WALLIS: Mike.

MR. SCOTT: Yes.

DR. WALLIS: Is any research going on sponsored by NRC?

MR. SCOTT: There is confirmatory research, some of which we will be reporting to you in the summer. I'll let Paul speak to that a little bit, if you would, Paul.

MR. KLEIN: We have continued to ask

Argonne National Laboratory to support us, and that support has included tests in a number of cases.

MR. SCOTT: So most of the testing that's NRC research that's still going on relates to chemical --

DR. WALLIS: Yes, I would think that if questions arose from this industry testing you might need to do some investigation yourselves.

MR. SCOTT: Potentially. We certainly have not made a decision that that is the path forward at this point, and I'll explain to you what the path is that we're going down, and that was another thing that was asked for a minute ago.

The licensees, most of them, with a few exceptions as I mentioned, asked for extensions from the staff to complete certain corrective actions, and you see the ones that primarily were addressed here. As I mentioned, they had not completed their downstream effects analyses, particularly in vessel. They need additional time in some cases to complete integrated head loss testing because of the staff's concerns with the test protocols and some of the vendors have struggled or been challenged to address the staff's concerns, and it has taken some time to sort all of that out.

And in a few cases, they asked for additional time to complete a modification. Most of the -- I would say essentially all of the strainer enlargements will be done this spring, and most all of them actually are already done, but two or three plants asked for time in early '08 to put in their strainers. So that will all be done.

There are additional modifications. In the case of one plant they need to change out some pump components that are vulnerable to downstream effects, and in another couple of plants they're changing their steam generators out in 2009, and they have a piece of insulation that's fibrous that they don't want to pull out twice because it's a heavy dose job, and they would prefer to do it when they change out their steam generators, and that particular piece of insulation would only be impacted by a limited set of potential LOCAs. So we found those acceptable.

So there are extensions, and you can see them on our Website for most of the plants.

CHAIRMAN BANERJEE: How many of them will have completed the testing by the time they complete the installation?

MR. SCOTT: The expectation is they will all have completed the testing by the time the last plant has made the last mod, and that's in '09. But let me be clear. A lot of them install the modifications before the testing because that was the industry's decision and the staff's decision supported by and directed by the Commission to get the strainers put in as soon as possible.

So it's kind of put us in a situation where you install the mod first and then go back and show that it's adequate, and that's obviously not where we would prefer to be in a perfect world, but the emphasis from two years ago at least was get the strainers enlarged, and you may recall the Committee considered that and agreed with that prioritization, and that's why we are where we are today.

CHAIRMAN BANERJEE: The issue then is what happens if your typical test indicates that something has to be done. You have to pull these trainers out and --

MR. SCOTT: I don't think that's the path that would be taken. If a licensee ultimately cannot show through a test that satisfies the staff that the test is concerted (phonetic), if the licensees can't use such a test to show adequacy, then they're going to have to make additional modifications, I believe. I don't think in most cases that would be a still larger strainer. I believe it would be along the lines of reducing the amount of problematic material that's in containment.

MEMBER MAYNARD: I think I recall from the previous meetings that we've had that the industry recognized there may be some risk with going ahead with this before the testing is complete. There may be additional modifications or changes that are needed. I think I recognized them before from what I recall.

MR. SCOTT: I believe that is correct, and I think the industry has understood all along that they would attempt to show success with the testing program. Hopefully that would work for them from their perspective, and if it does not, then they'll have to reconsider, and my personal opinion is -- and this is based on conversations with some licensees -- that they're not likely to go back and take a 6,000 foot strainer and make it into a 10,000 foot strainer. I think they will remove fibrous insulation. I believe that, but that's my personal view.

We certainly have not directed that.

CHAIRMAN BANERJEE: Or the buffer or something.

MR. SCOTT: Or it could be, yes, that's

correct. Some of them have changed the pH buffer and others could choose to do that as a possible part of a solution, yes. It's plant specific. As we said to you before, the severity of the challenges posed by this issue varies dramatically from plant to plant. Some have virtually no fibrous insulation to begin with. Others have lots of it, and so the solution, we can't direct a particular solution from here. The licensee needs to sort out how best to address the problem, and it may be iterative in some cases.

CHAIRMAN BANERJEE: That's why these tests are pretty key.

MR. SCOTT: Yes.

CHAIRMAN BANERJEE: And the fact that they're representative in some sense.

MR. SCOTT: They need to be the expression we use is prototypical or conservative.

CHAIRMAN BANERJEE: Right. I remember the discussion we had at the last Subcommittee meeting on that.

MR. SCOTT: Right.

CHAIRMAN BANERJEE: And it's very hard to approve that or that they are conservative.

MR. SCOTT: It is a challenge, as I said a minute ago. It's a challenge to show a conservative test without embarking on an extremely conservative test that you may or may not get a good result with, and you know, there are so many areas in this issue, so many subject area, debris generation, debris transport, chemical effects, coatings, and it goes on and on, and if you have conservatisms in every single one of those areas, you're going to have a significantly over conservative test, and if you're a high fiber plant, that might be a problem for you.

So then you have to design a test that you show is conservative but is not accessibly conservative.

DR. WALLIS: Well, the question which was actually raised was raised by industry about these very large strainers is that the very large strainer, yes, you solve the head loss problem, but you might increase the bypass problem. You've got much more area for the fines to get through, which lead us into the presentation we're going to have later today.

MR. SCOTT: That's correct. I would defer discussion of that. Let's let Dr. Landry convince you that that's been handled and Mr. Klein.

Okay. Going on about extensions, most of them are for a few months, a couple into 2009 related to modifications, as I mentioned. We anticipate based on the current extensions that we have that the testing will be done in the first half of this year. It is not beyond the realm of probability that some plants will ask for additional time for completing the testing because we are still trying to observe testing at some of the vendor facilities, and those observations could result in additional needs for revisions to the test protocols.

This is not, as I said, coming all together at once as we would prefer it have done.

Regardless of whether they got extensions, we asked that all plants provide us supplemental generic letter responses by February 29th, and we have essentially gotten all of those responses, and we're going to be reviewing them, and that is the focus of our efforts for the next several months.

Speaking of chemical effects, many plants -- I've already said this -- did not complete their integrated head loss testing, including chemical effects, by the end of 2007.

How did we get to that point? Well, I've discussed some of these things. Some of them I have not. Late recognition by the industry of the difficulty of the issue; there are only so many test vendors. So the licensees are having to queue up in order to get their testing done.

As I mentioned, there have been challenges resolving staff issues with I mentioned the protocols, but also the staff had some concerns with the chemical effects topical report.

I'm happy to report that has all been sorted out, but it took some time to do that. The staff did issue a final safety evaluation on WCAP 16530 in December 2007.

Chemical effects peer review. This is a subject have talked about with you several times. The staff screened the peer review issues in 2007 to identify those warranting further evaluation. Research commission and study of aspects of that, of those peer review comments that the earlier staff review could not disposition, and we're looking at the study results now.

That study may result in identification of the need for additional confirmatory work in some areas. That's a little bit premature to say because we're still looking at it, but I think that's a possible conclusion.

We will discuss this report and the staff's review of it with the Committee later in 2008. I anticipate this summer.

CHAIRMAN BANERJEE: Will there be any issues there that could impact today's meeting?

MR. SCOTT: We're not aware of any.

Paul, do you want to speak to this?

DR. WALLIS: I'm wondering about this confirmatory work. I mean, ANL does a test of chemical effects. They show an enormous effect, but then when you do something more realistic with a real screen and real or supposedly real conditions, the chemicals don't build up uniformly and everything, and nothing is quite so bad.

So it's not quite clear what's being confirmed by ANL. It's so different from what really happens.

MR. KLEIN: We can get into that a little bit later in my presentation, but part of what we asked ANL to do was to evaluate particular aspects of the 16530 approach, for instance. We tried to benchmark the WCAP aluminum oxyhydroxide and sodium aluminum silicate precipitates against what ANL had previously tested and what we had observed in ICET because one of the staff concerns was that a number of integrated head loss tests might be run with a precipitate, and we didn't have a good understanding of how it behaved in head loss space.

So, you know, in conclusion there, I think we found that industry had developed a precipitate that was conservative, and it does drive up head loss very dramatically in the vertical head loss loop at ANL.

Our experience with the much larger scale integrated test in industry is that there is an effect, but it is not as dramatic as what we've observed with the flat plate and a vertical head loss loop.

CHAIRMAN BANERJEE: This must depend a lot on the geometry of the system because there are industry sump screens which are put down in the sump and the flow is coming from the top, say the top hat configurations. You know, I think it is very geometry dependent what happens there.

MR. KLEIN: It's clear to say there's a number of factors that impact it: the strainer design, for instance, whether it's a uniform flow strainer or not a uniform flow strainer, the debris bed that forms, the amount of chemical precipitate. So it has been a very plant specific issue, and part of what is delayed, the whole GSI has been trying to sort out the different industry approaches and make sure that the staff has an understanding of how the tests are conducted and how the results are interpreted.

CHAIRMAN BANERJEE: Yeah, I recall that even issues like how much turbulence there is, whether these things can stay in suspension or they settle out. All of that stuff is to matter and how to make that prototypical, very simple, right?

MR. KLEIN: One of the things we'll discuss later in my presentation is one of the conditions and limitations that we put on the industry with respect to settlement of their precipitate.

CHAIRMAN BANERJEE: Okay.

MEMBER ABDEL-KHALIK: Has there been any attempt to group the plant responses into categories of responses rather than treating each plant individually as unique?

MR. SCOTT: You might say that we've done that informally in that if a plant has reported completion, we're putting those to the front of the queue simply because if a plant has not reported completion, they haven't done their testing, we're not really going to be able to reach a conclusion as to whether they've resolved the issue or not at this point.

So we're focusing right now on the plants that have reported completion. That's driven by the fact that a number of them are not complete.

Does that answer your question?

MEMBER ABDEL-KHALIK: No, not really. I'm trying to see how one would go about doing meaningful, confirmatory tests.

MR. SCOTT: Oh, all right.

MEMBER ABDEL-KHALIK: And the issue then would be can you sort of bend the responses into different categories so that you can define appropriate confirmatory tests for each group of plants rather than each individual plant.

MR. KLEIN: My response to that question would be that, yes, we have been them, but it has been previous to when a submittal comes in. By reviewing all of the industry test protocols, we have grouped the individual plants by what test vendor and what test approach is being used, and so there's ongoing interaction between the staff and that set of licensees using a particular test approach.

Since each test approach has certain strengths and weaknesses, we found that the most efficient way to try and evaluate the approach taken by a given licensee.

CHAIRMAN BANERJEE: Since there are a

limited number of vendors, I assume that there's a limited number of screen designs or they're deployed somewhat differently in different plants, right?

MR. SCOTT: Yes.

CHAIRMAN BANERJEE: Even on the same screen.

MR. SCOTT: Yes, that's correct.

CHAIRMAN BANERJEE: And there are upstream effects and so on that can affect how these screens behave. I guess my take on Said's question is whether you could sort of bend these in some sense based on the screen design or are other upstream effects so important that you can't do that?

MR. SCOTT: In effect, we have already done that in that we are addressing each vendor's test protocol by vendor. So, for example, one of the vendors is PCI. Another is CCI. We are visiting tests, representative tests at each of those vendors' facilities.

Our assumption is that a similar test, although not identical, will be run for each one of the customers of that given vendor. Now, it is possible that because, as you pointed out, some of the sumps are in a pit and others are not in a pit, and so on, that there could be significant variations within a vendor's customers.

But by and large, you have one design per vendor, and you have typically one test facility or set of test facilities for that vendor. So by going to that vendor's facility and reviewing that vendor's test protocol, we are doing, I believe, in effect, what you're talking about.

We have binned them by vendor, which captures the issues that are associated with each vendor because that's the way it plays out. Each vendor is different. Each design is different, and the issues identified are different, although some of them carry over from one vendor to another.

So I believe we're doing that.

Speaking of downstream effects, we talk about downstream effects in terms of ex vessel and in vessel. Ex vessel refers to the potential for debris to either clog or damage downstream components outside the vessel. We did issue a final safety evaluation on ex vessel downstream effects in December 2007. That was one of the activities that some of the licensees indicated they need additional time to complete and was the subject of some of the extension requests.

With regard to in vessel or core flow blockage effects, we received the topical report for the PWR owner's group in June 2007. We have undertaken a detailed, but still accelerated review to attempt to get this document reviewed and a safety evaluation issued, and we just now issued the draft safety evaluation which is the same of today's meeting.

So obviously the rest of today after I'm done we'll be speaking about that subject.

With regard to coatings --

DR. WALLIS: Excuse me. You have a safety evaluation of what we're going to look at today?

MR. SCOTT: Yes, which we provided to you all.

DR. WALLIS: Are you going to present your results today or are we just going to listen to Westinghouse?

MR. SCOTT: No, the staff will discuss the safety evaluation.

DR. WALLIS: Oh, you will. Okay.

MR. SCOTT: Yes.

DR. WALLIS: Which we have not seen or have I missed something?

MR. SCOTT: No, you have seen it or the Committee was provided that report a month ago.

CHAIRMAN BANERJEE: We have it, Graham.

Do you not have a copy? Have a quick look at lunchtime.

MR. BESSETTE: You should have gotten it. It looks like this. It's only a few pages.

CHAIRMAN BANERJEE: And the conditions are only one and a half pages, which is surprising.

DR. WALLIS: I don't think so.

MR. SCOTT: Okay. The next subject is coatings, protective coatings, paint. The staff has reviewed several technical reports from the industry on coatings and has accepted certain methods and refinements proposed.

We have issued draft review guidance and are preparing to issue final review guidance on coatings, and the final review guidance is effectively unchanged from the draft review guidance.

So we believe on the coatings issue that licensees currently have enough information and guidance to satisfactorily address coatings issues.

Head loss testing. We've already talked about this somewhat, and we'll talk to you about it in significantly more detail this summer. As I mentioned, the staff has questioned certain aspects of the licensee sponsored, vendor performed head loss testing, and again, our standard is that the testing needs to be conservative approach typical.

Areas among which we have had concerns have included debris preparation, seeking credit for near field settlement. Some vendors do; some don't. And also with regard to conducting thin bed testing, for those less familiar with the term, that refers to a thin -- and it turns out it can be very thin -- bed of debris potentially including chemicals on a screen that can lead to significant head losses.

CHAIRMAN BANERJEE: With regard to debris preparation, I know that for some obscure reason you wanted this quadripartite meeting that we had in Germany. There was quite a lot of concern about the distribution of fiber sizes and particle sizes and things like that, and there was work going on both in Germany and Japan to try to characterize this better, what was realistic and what was not.

Have you had any interactions with colleagues in these countries other than just sort of hearsay?

I know you were in Germany for a meeting.

MR. SCOTT: No.

CHAIRMAN BANERJEE: You did not?

MR. SCOTT: No, but to answer your question, yes, we have. We did meet with the German folks and got some of their information. They have very different conditions in their plants from ours. For example, they don't have a pH buffer, and they have very different chemical species in their plants and a different regulatory regime as well.

But we have met with them, and we are, coincidentally, we are leaving for Japan. A three-person team is going to Japan the first week in April to get the latest information from them.

CHAIRMAN BANERJEE: Right. I realize there are chemicals, and they don't have to consider large break and all that sort of stuff, but --

MR. SCOTT: They also can't take a heat-up.

CHAIRMAN BANERJEE: Yeah, they can't take any heat-up, and therefore, downstream effects are much more serious for them than for us.

MR. SCOTT: Potentially, yes.

CHAIRMAN BANERJEE: But the generation of the debris itself in terms of the sizes and the size spectrum and the fiber lengths, the distribution, that's an area where there seems to have been a lot of concern, that our understanding was very poor in that area.

MR. SCOTT: To be honest, I don't recall

that being a subject. It may have been. It's been several months since that meeting occurred.

Clearly, our staff has had concerns about debris preparation, which I'll talk a little bit about today. I'm not off-the-cuff aware of what a German concern might be in that area, but I'll go back and look at the information we have from them and see if there's anything else.

CHAIRMAN BANERJEE: They've even said -- there's a recent letter where they've asked for any data we have to exchange some data that they have. I'll forward it to you and you can have a look, but on that --

MR. SCOTT: They asked you?

CHAIRMAN BANERJEE: Well, what happened was when we went to this meeting, they had a lot of information which they presented, which I've tried to have forwarded to you.

MR. SCOTT: And you did. I mean, I now have that.

CHAIRMAN BANERJEE: Okay. And we also asked them if they would be so kind as to send some of their reports and things on these experiments that they've done. However, apparently the utilities had supported some of this. So they came back asking for some data exchange in some sense, and the area that they were more interested in was related to debris generation and the size distribution and things like that.

Anyway, that's just beside the point here, but it emphasizes that there was a great deal of interest in that area.

MR. SCOTT: Okay. Thank you.

I am not aware that the staff has received an information request from them on that subject. If --

CHAIRMAN BANERJEE: No, you haven't received anything.

MR. SCOTT: Okay, okay.

DR. WALLIS: Mike, I'm looking at your memo that states that you want to issue a final SE by March 31, which means the only way that the ACRS can have any influence on this SE is through the subcommittee at this meeting.

MR. SCOTT: Well, let me put it to you this way. It ain't going to happen by March 31st.

DR. WALLIS: Well, are you expecting the ACRS to have any input to this SE?

MR. SCOTT: Yes. So what I'm telling you is disregard that date, please. We don't believe the report is going to go out by then, and there will be time for you all to provide us a letter.

DR. WALLIS: Is there anything else I should disregard?

(Laughter.)

MR. SCOTT: GSI 191 is an issue where the facts change from time to time, and the situation changes from time to time. I'm not aware of anything else in there you should disregard.

Speaking of head loss testing, as I mentioned before, the staff's questions and concerns have had impacts of licensee test schedules. Licensees can use any approach that they can show to be conservative or prototypical.

Now, that said, the staff believes that some approaches are not conservative and our perceptions of that have changed based on new information, and that has caused some angst in the industry because the staff previously would have thought, for example, that adding fiber first would be an acceptable approach for developing a thin-bed test. We now don't believe that to be the case because it appears that adding particulate first results in a significantly higher head loss.

Now, if a licensee can show that fiber

first is representative of their plant, then they can use that for a test. We're not sure they can.

DR. WALLIS: Well, particulates first probably adds to the downstream effects, doesn't it?

MR. SCOTT: It could.

DR. WALLIS: It could go through before there's a fiber bed to catch them.

MR. KLEIN: I think that all particulates assume to pass through the strainers.

DR. WALLIS: Yes, and then they go all the way around the loop and come back to the --

MR. SCOTT: To the testing, yes.

DR. WALLIS: All right.

MR. SCOTT: They circulate around in the loop until the fiber comes in.

One recent test of a uniform flow strainer that we observed, and the test was conducted by adding the full particulate load followed by only fine fiber, to create a thin bed, which was the objective of the test, resulted in a high head loss without the addition of chemicals.

That was new information to us. The magnitude of the head loss was quite high, and we hadn't expected that, and that gave us concern about that particular scenario.

Now, we do not believe that in the plant that what actually happened is that the particulate would all show up before any fiber showed up.

DR. WALLIS: This is typical. Every time anybody does a new test, you get something which surprises you. This has happened. There's a whole cycle of this going through history.

MR. SCOTT: There have been many surprises in Generic Safety Issue 191, yes.

We do not know at this point the implication of that test result for other designs and plant specific conditions that are currently under review. The plant in question is attempting to design and have the staff consider it to be conservative, a new protocol to address the fact that they got a high lead loss from this clearly overly conservative protocol that they ran through.

CHAIRMAN BANERJEE: Is there any explanation for why that happened?

MR. SCOTT: I'm going to try to remember this, but actually, is Steve Smith in the audience?

Okay. Matt Yoder of the staff will step -- I'll probably get it wrong if I try to go through it.

DR. WALLIS: It did happen at Pacific

Northwest, didn't it? I mean, they did the same test. Surprisingly that's when they got the highest pressure drop.

MR. KLEIN: That's correct.

MR. YODER: Matt Yoder, NRR staff.

The staff understanding of why you get this, let's take a test where you have just fiber in the loop first. On the plate, on your strainer, you start to accumulate fiber. One part of the strainer is going to have slightly higher flow than the other just because whatever is closer to the suction is going to accumulate more. So in a just pure fiber case, you're going to build a fairly tick bed of fiber before that flow redistributes to the barer portion.

If you have a case where you have the particulate in it first and the particulate and the fiber are building at the same time, it's going to take a thinner mat before that starts to redistribute to the other portion.

Does that makes sense?

CHAIRMAN BANERJEE: Yes.

MR. YODER: That's our understanding of the phenomenon.

CHAIRMAN BANERJEE: So if you start with mixed particulate and fiber, that that should be worse than starting with pure fiber.

MR. YODER: That's our understanding at this point.

CHAIRMAN BANERJEE: And when you put particulates in with pass-through, with screen in any case, you're more or less doing a mixed fiber and particulate.

MR. YODER: By having the particulate in there first, you essentially have that particulate thoroughly distributed throughout the whole loop, and then the fiber is coming afterwards.

MR. SCOTT: To emphasize the point I made a few minutes ago, the fact that there is a conservative protocol which involves putting all of the particles in first followed by the fiber, the fact that that is conservative does not mean that a licensee has to do the test that way, but again, I'm going to sound like a broken record here. They need to show that their test protocol is either conservative or prototypical for their plant's conditions and trying to figure out the debris sequencing can be a challenge.

CHAIRMAN BANERJEE: Has there been any sort of pick-up of the downstream passing of fibers? If you had a hole of .1 inches, say, do fibers longer than .1 inches go through?

MR. SCOTT: There is a distribution of that. I'm not sure that we have the right folks here to answer a question of that sort today. That is in the ex vessel topical report. I believe there is some mathematical approach to that. I couldn't tell you what it is off the cuff, but it is in WCAP 16406(p) and the staff safety evaluation for that.

DR. WALLIS: In view of all these phenomena that we keep talking about and discovering, it's a bit odd to me that one accepts one cubic foot of bypass per thousand cubic foot of debris as some magic number which always works.

MR. KLEIN: I think part of that is based on a wide range of bypass tests that have been done for a number of different strainer designs, and sampling and filtering and what passes downstream and that provides a basis for the number.

CHAIRMAN BANERJEE: Is that averaged over a long period of time or is it sort of a transient number?

I noticed that number, too. It seemed --

MR. KLEIN: I think the experience has been -- and I'm certainly not the downstream expert -- but the experience as I understand it has been that there is a large amount of bypass initially until you build up a fiber mat on the strainer, and then a dramatic decrease in the amount of bypass over time as you build a filtering bed.

DR. WALLIS: So if you had a plant that had no fibers, what would happen?

MR. KLEIN: You would probably assume that all particulate would pass the strainer and account for it.

MR. BESSETTE: Excuse me. I'm one of those folks who are new to this discussion.

Other than the event over in Sweden some years ago, have there been any other real events or any testing done to see what the debris really might look like in real events?

MR. SCOTT: The only PWR event, and it's not really analogous to this situation where you're recircing off the floor, is Three Mile Island, of course. There have been no challenges that would speak to a high energy line break and a PWR that causes the sump recirculation.

DR. WALLIS: But TMI was completely different. TMI --

MR. SCOTT: That's right.

DR. WALLIS: -- the leak went into a tank.

It didn't go into the containment.

MR. SCOTT: Well, I think ultimately it did go into the containment, but I don't think they recirced off the floor.

DR. WALLIS: When the tank ruptured.

MR. SCOTT: Right.

DR. WALLIS: But that's a different place altogether from the pipes that are near the insulation on the steam generator and so on.

MR. SCOTT: Yes, I agree. TMI is not analogous to this. So the short answer to your question is, no, there have not been challenges of this sort.

Supplemental response reviews. That's what I mentioned we were going to be doing the next five to six months. The typical package is somewhat over 100 pages long, and we're going to review them all. We are doing a fairly detailed review of them, and it's going to take a fair amount of time to get that done.

DR. WALLIS: So by the time it's all done, you'll have a completely new ACRS.

Will you have the same staff working on this all the time? Staff moves around in NRC in peculiar ways. Are you making sure that the people like the man next to you on your left sticks with this until it's finished?

MR. SCOTT: We like to think of joining the GSI 191 team as a one-way ticket.

(Laughter.)

MEMBER CORRADINI: To where?

CHAIRMAN BANERJEE: Paradise.

MR. SCOTT: I mean, let me be honest. That's an interesting question. It is an issue that the staff has not just with this issue now, but throughout the agency there is a lot of movement because of promotion opportunities. That's great for the staff. It's a challenge for managers.

We have what I consider to be a very strong, exceptionally strong GSI 191 staff team, and any time we take a loss for one reason or another like that, it's a big deal for us. It is.

However, I would point out that Paul has been involved longer than I have. I've been with this two years. He's been with it significantly longer than that I think.

Several of our other folks have been here for the duration of 191. So the staff considers GSI 191 to be a top priority, and we focus on that with regard to staffing decisions as well, and that top notch team is going to be doing these reviews that we're talking about.

CHAIRMAN BANERJEE: Well, some of that top notch team that we saw in Maine we don't see here, and we understand has moved away since that time. Have you replaced them obviously?

MR. SCOTT: Yes, true statement, and that's going to happen.

CHAIRMAN BANERJEE: Right.

MR. SCOTT: Although I'd like it to be a one-way ticket, it's not. I mean, that's the reality, that folks move on, and we just have to deal with it just like any other area, and this one has the additional challenge of having gone on so long that we've had, you know, over time there have been some significant changes.

But I would say that there is a lot of stability in the 191 team here.

CHAIRMAN BANERJEE: Do you have access to some of these people who have moved into, say, NRO or something at least in an advisory capacity?

MR. SCOTT: That gentleman on my right

CHAIRMAN BANERJEE: On your right I noticed a white-haired gentleman.

MR. SCOTT: Yes, Ralph Landry is the

person who developed that SE, and he put the wrong date on it. So I'll have to have a chat with him about that.

(Laughter.)

CHAIRMAN BANERJEE: Now, when you go to NRO, I guess, things get much more hectic. That's why he doesn't have time to look at the dates and things.

MR. LANDRY: When I've moved over to NRO, part of the agreement was that I would continue to help out on this project. When I moved over, I promised Mike and Bill Ruland, both, that I would continue to support this effort until it was finished.

My management in NRO has been very cooperative with that.

That was, in part, because of this issue of the high turnover. A person had started on this project when it began back in June as Mike was talking about when the report first came in. That person moved to NRO. They then, because of the expediency of this work, asked if I would replace him, and agreed but did not realize it was a one-way ticket at the point, but when I moved over to NRO, realized that this was important work, and I agreed to continue to support Bill and Mike in this and make sure that there was not another turnover in reviewing this material.

MR. RULAND: Good morning. I'm Bill Ruland. I'm the Director for the Division of Safety Systems, and I have the pleasure to work with these good folks.

Just as another example of knowledge management that we're facing, we have two of the three senior level advisors that I have in the division. Jim Bell and Tim Collins are both involved in what's called the integration review teams associated with this work, and we specifically decided to get them involved in this so they would become familiar with the issue and they would learn this issue -- I think Jim is in the room -- specifically so we can bring them up to speed.

And these folks are very seasoned NRC employees who have been with the agency for a long time, and we're continuing to do that kind of effort, but I agree with you. It is a challenge, and we try to have an environment that these folks would like to say and work on this issue because of, frankly, the technical and regulatory challenges it poses. I think it is really a unique experience for all of them, and so far the strategy has proved successful, but we're not going to let it set there.

Thank you.

MEMBER ABDEL-KHALIK: Going back to the issue of conservative or prototypical test protocol, given the large uncertainty as to the initial configuration, order of arrival, et cetera, is there any way for a licensee to develop a test protocol that is defensible other than the most conservative?

MR. SCOTT: The staff has accepted some assumptions along that line, such as homogeneous or simultaneous arrival. You are correct that there are many different possibilities, and certainly you can't design a test for every possibility.

We've provided guidance to the licensees several years ago regarding debris preparation, debris generation, debris transport, and so on, that evaluated actual an NEI guidance document that attempted to address those issues, and we believe that the assumptions made there and that the staff bought into are conservative.

A licensee can choose if they can support it to bring back some of those conservatisms with a different protocol, but back to the same thing. They need to show that it's conservative, prototypical. In some cases that's quite challenging to do, as you mentioned.

CHAIRMAN BANERJEE: See, if I recall the

May meeting, licensees were taking a variety of approaches. One of them, of course, was to remove insulation if possible, which seemed like a great idea.

The other was -- when they could do it, obviously.

MR. SCOTT: Yes, right.

CHAIRMAN BANERJEE: The other was if they couldn't, to do some fairly ad hoc tests to show that the debris generation was smaller and the zones of influence were smaller than had been legislated in the various documents.

You know, I recall there was quite a lot of work in that direction.

MR. SCOTT: That's correct, and some licensees have purchased vendor provided analyses that showed that the ZOIs, zones of influence, were in fact smaller than was assumed in the staff's review guidance, and the staff has looked at some of those.

CHAIRMAN BANERJEE: Or they did some tests or something.

MR. SCOTT: Well, yeah, a test that would be the subject of the report.

CHAIRMAN BANERJEE: Then a third way that they were proceeding was to calculate quite a lot of dropout if they could. I recall one presentation where they were putting the flow through the instrument tunnel, hoping that much of the debris would drop out there due to centrifugal effects or whatever, sort of curved.

MR. SCOTT: Right.

CHAIRMAN BANERJEE: And that required some quite interesting CFD calculations considering that we don't know how a particle moves through a turbulent fluid even today. I was wondering how that was being done at that time.

And it was then taken that whatever was going to be delivered to the strainer was after all this stuff had dropped out.

I'm just wondering in extension to Said's question whether the most conservative approach in these situations would be to simply not take all the debris and have it delivered because really it's very hard to estimate how much would be dropped out.

MR. SCOTT: Well, the interesting thing is that the worst case --

CHAIRMAN BANERJEE: Is not that case.

MR. SCOTT: -- is not always the same case. For example, the worst case for forming a you might call it design basis debris bed, you know, where you send all of the debris in, is not necessarily going to be the same preparation technique as when you're trying to obtain a thin bed for a test.

And it turns out as I mentioned earlier that fine fiber can be particularly problematic in a thing bed environment probably much more so than for a full, thick debris bed. So it is all quite complex, and it's specific to the plant materials.

That's why there is no one solution to GSI 191.

DR. WALLIS: How about the break size and location? When we went to Germany, there was some indication that some of the smaller breaks might be more challenging than the big break for the sort of reason you discussed here. When you've got different debris mix, you get different amount so debris, different timing, and it may turn out to be -- in fact, some of them there claimed that this was worse than the big break where a lot of stuff goes there, and the screen is big enough to hold it all.

MR. SCOTT: Yes. That's exactly right, and that's why we expect a licensee who cannot show that they have significant clean strainer area with the full debris load, to conduct a thin-bed test to attempt to address that situation where you get a lower debris load and, in fact, a thin bed head loss could be larger than a full debris bed head loss. You're absolutely right.

So we expect them to evaluate both.

Speaking of the extensions and so on, because we got responses from all the licensees in February, it is likely that we will get additional responses reporting completion of the testing so that we may have to go back and look at plants that we've already looked at as we go through this process.

So the reviews are going to in many cases be iterative before we can reach the conclusion that a given plant has satisfactorily addressed the issues. So I say March through October '08 in this slide show.

Graham, please don't hold me to that. There might be some slippage in that depending on what we find.

DR. WALLIS: Well, by the time this is over I won't be here to hold you to anything.

MR. SCOTT: No comment.

On Slide 13, the staff plans to close these issues on a plant-by-plant basis based on the following three things: conclusions of our review of the licensee supplemental responses, results of region inspections, and what those inspections at the region do is simply verify that the licensee made the changes they committed to make. It's not a validation or a verification of the adequacy of the corrective actions.

And then the third thing is review of licensee responses to audit open items as applicable. I had mentioned we'd done nine audits, and we talked about binning earlier. We binned the audits. We binned the plants to make them the subject of audits based on how they fell out, for example, and which vendor they used, what type of strainer design they had and so on. So we attempted to get a sample of all of the vendors' activities because they are vendor specific.

If a plant has one or modifications yet to do but has shown us through an evaluation that they have adequately addressed the technical issues and that their plant will be in full compliance when the last modification is made, we plan to close the generic letter and GSI for that plant.

To restate that bullet, we don't plan to hold that open for that plant until the last mod is done if the solution is visible to us and has been shown to be adequate.

The staff will track all corrective

actions to completion at all plants. So we're not going to walk away form this until they're all done.

Here is a tentative time line. Just speaking, most of these things I think I may have already talked about. We're doing the SE now for in-vessel downstream effects. April '08, final SE issued. We will, of course, look for your letter before we do that.

April to June 2008, limited scope audits I have already talked about. Region inspections wrap up in June.

Summer '08, as I'll talk about a little further in a few minutes, we plan to come back and talk to you about testing and other closure activities.

August '08 we get the inspection results. A couple of months later we wrap up if the information is sufficient. We wrap up the final supplemental response reviews to support issues of closeout letters by November and management concurrence on closing the GL and the GSI by December '08.

That obviously depends on a number of things coming together, and as several people have said, there's the track record in this issue of sometimes that doesn't happen. So --

DR. WALLIS: May I ask if any managers go and observe these tests so that when they approve a document they have some idea of what it's based on?

MR. SCOTT: I have been on one I will say. A lot of these facilities are overseas, and constraints dictate that we not send large teams overseas. However --

DR. WALLIS: It just seems to me that it's a big enough issue that it might be worthwhile for a manager to see some of the things that really happen in these tests.

MR. SCOTT: Can I have that in writing?

CHAIRMAN BANERJEE: Do you want it as part of the ACRS letter?

MR. SCOTT: No.

(Laughter.)

MR. SCOTT: I was just thinking maybe a personal endorsement.

DR. WALLIS: They really are overseas? I thought there were quite a few tests in this country.

CHAIRMAN BANERJEE: Or Canada.

MR. SCOTT: Well, Canada is one. Switzerland is another. What is it Czech Republic?

DR. WALLIS: Isn't the New Jersey --

MR. SCOTT: Slovakia.

DR. WALLIS: Is New Jersey still in the union?

(Laughter.)

MR. SCOTT: There is a test facility that one of the vendors uses in New Jersey, but three of them are overseas, and it's not --

DR. WALLIS: Well, we can go to New Jersey. That's not too far.

MR. SCOTT: And I have been to New Jersey. Thank you very much.

CHAIRMAN BANERJEE: Is there only one facility in the U.S.?

MR. SCOTT: No, there are more. There's -- Allian has a facility ind Chicago. What else? PCI is in Massachusetts.

DR. WALLIS: I wouldn't go there.

CHAIRMAN BANERJEE: And Aciel (phonetic) or where is the --

MR. SCOTT: Say again.

CHAIRMAN BANERJEE: -- Canadian facility?

MR. SCOTT: Chalk River in Canada, yes. For NRC purposes that is an international trip.

CHAIRMAN BANERJEE: Even thought it is less expensive than going to Massachusetts.

MR. SCOTT: No comment.

MEMBER CORRADINI: And more pleasant.

MR. SCOTT: No comment.

If we could move on to Slide 15, please.

Proposed subjects for summer 2008, ACRS review.

Integrated head loss testing protocols results. We hope to come in to you this summer and give you the results of our reviews of the test protocols. We hope that the issues have been resolved and we have observed and evaluated --

DR. WALLIS: Okay. Now, are there any tests in support of what we're going to hear later today? I mean, there's this tremendous number of tests on screens. What about tests on cores?

MR. SCOTT: Can you defer that question until Dr. Landry and Mr. Klein speak? There has been a test, a demonstration test.

DR. WALLIS: Well, I looked for that. I look for evidence, and I've got all of these assertions and things about the core, and I looked for evidence, and I didn't find very much.

MR. SCOTT: Well, again, I would ask that you defer that question to this afternoon --

DR. WALLIS: Okay, okay.

MR. SCOTT: -- and this morning. Okay?

DR. WALLIS: Thank you.

CHAIRMAN BANERJEE: Now, in this integrated head loss testing protocols and results, you also presumably have results on bypass at that time.

MR. SCOTT: There has been bypass testing, yes. It's plant specific.

CHAIRMAN BANERJEE: Yeah, and so you would have some more information on what gets to these streams at that time.

MR. SCOTT: Okay. Yes. We also plan to talk to you about staff review of the licensee supplemental responses and how that's going. We plan to discuss the results of the staff's review of the chemical effects peer review which Paul and I referred to a few minutes ago.

Paul will plan to provide you the results of additional confirmatory chemical effects testing in Argonne.

Other subjects of interest to the committee are identified, and you just identified one. And if the information available that that time in the staff's judgment supports, we would plan to seek a letter from you regarding readiness for issue closure, if warranted.

CHAIRMAN BANERJEE: Now, at the last Subcommittee meeting, it was at least to me very useful that you showed us how typical three or four representative plants were handling this matter because of them had a rather different way of doing it.

MR. SCOTT: Yes.

CHAIRMAN BANERJEE: And it illustrated the difficulties and the problem and the various approaches. When we are going to be talking about this head loss protocol, would you be presenting results for a typical plant as you did before to illustrate the sort of things that were being done or how would you handle that?

MR. SCOTT: Oh, I would say that depends on the level of detail you're interested in hearing. The way you heard it before was the industry presentations.

CHAIRMAN BANERJEE: Which was very good, by the way.

MR. SCOTT: Yes. If you're interested in that kind of level of detail again, then I would suggest that you ask the industry to come in again and make presentations on a sample of their final work. We can certainly summarize what we find in the generic letter supplements and we'd be happy to do that, but of course, that's a reference rather than the original work that was done. So it kind of depends on how you all would like to play it.

Do you have an opinion at this point or do you want to think that over?

DR. WALLIS: How much of it is in the open? Is this available to the public all of this head loss testing and the submittals from industry and so on?

MR. SCOTT: Consistent with requirements for proprietary information and sensitive information, by and large the generic letter submittals that we got in February are or will be available to the public.

DR. WALLIS: They will be available?

MR. SCOTT: Yes. Now, there are a couple of them who have identified some proprietary information, and we have a process for dealing with that.

DR. WALLIS: So these submittals and your review of them will be all public documents.

MR. SCOTT: The results of the review and the closure to the licensee and the licensee submittal will be available to the public, yes.

DR. WALLIS: So whether or not we get a

presentation, we can actually read some material.

MR. SCOTT: Yes, and you'll be able to read the materials in the near term because we are posting those generic letter submittals now on the Website, and of course they're in ADAMS on the public side as well.

But I would sort of put a caveat on that, that those are summary level information. A typical submittal, as I said, is 120 or 100 or so pages, and that sounds like a lot, but when you get down into their 12 or 13 areas, it's a summary level information on each one, and we have not yet established whether we have gotten sufficient information in any of the plants because we have just started the reviews.

So you may find that you want more information than those packages have, and if you would like to have the industry or licensees come in and make a presentation, I'm sure they'd be willing to do that. Otherwise we will talk to you about it.

DR. WALLIS: So what's available publicly will not be actual results of tests and actual justification for why this is conservative or not conservative and why it applies to the plant and how it applies to the plant?

MR. SCOTT: No, that will be.

DR. WALLIS: That will be there?

MR. SCOTT: That's the argument that they are making to us in their submittals. So that information will be there.

Now, again, we haven't reviewed it. So we may find issues with some of it, and as we do, we may have RAIs and responses, but all that stuff will be public, too.

DR. WALLIS: So some student in a university could review this stuff.

MR. SCOTT: Sure.

MEMBER MAYNARD: Well, I would be surprised if there's not some of the submittal that will be proprietary for some of them. When we were going through the vendor testing, I know there are a couple of presentations that had some proprietary information. Some were not.

MR. SCOTT: I would say that one or two of the vendors are somewhat more sensitive to that than others, and so we have a few packages that have been submitted proprietary. It's very few.

MEMBER MAYNARD: But nonetheless, the ACRS would still be able to review any --

MR. SCOTT: That's correct.

MEMBER MAYNARD: -- proprietary

information.

MR. SCOTT: You just wouldn't be able to see it on the Website, and the way we work proprietary information is we review the information that's asserted to be proprietary, and then there's a process that we use to go back and forth and figure out what really is proprietary, and there could be a redacted version that's released to the public with the proprietary information omitted.

MEMBER MAYNARD: I know it, but the fact that the vendor wants it to be proprietary doesn't necessarily mean that it gets ruled as proprietary.

MR. SCOTT: Absolutely not, because we have a primary interest in making this information visible to the public, but like I said, most of them -- and all of these packages are here now -- I think maybe three out of 40 are identified as having proprietary information.

DR. WALLIS: These are available presumably in electronic form. So they're very accessible.

MR. SCOTT: They are PDF files. Some of them are big PDF files.

Another issue I'd just like to touch on briefly today just to keep you aware, but I think I mentioned this to you perhaps in May of last year. If you go back a ways on this issue, you know that originally back in the 1980s PWR strainer issues were considered, and actions were taken and the issue was considered resolved.

Then the events happened at I think a couple of BWRs back in the early 1990 that led to evaluation of BWR strainer issues and the potential of clogging from debris.

There were two NRC bulletins that went out at that time, and the industry resolved the issues for BWRs in the late 1990s, and the NRC accepted that resolution in the late 1990s.

However, as a result of information we obtained in resolving the BWR issues, we said, well, let's go back and consider what we did in the '80s for the PWR issues, and that resulted ultimately in the issuance of Generic Safety Issue 191, and here we are several years later.

Well, the result of all of that is that for various reasons the treatment of debris induced clogging issues has varied from two reactor types. A different strainer design, of course, a different ECCS design, different core design causes different issues, and that potentially can result in disparate treatment.

Also, frankly, the issues were addressed at different times and based on different states of knowledge. So we've learned a lot from the PWR work, and so that has led inquiring minds to ask what is the potential applicability of that information to BWRs, and I believe that the industry had actually been starting to think along those lines as well.

NRR has sent a user need to ask the Office of Nuclear Regulatory Research to evaluate these differences and recommend additional actions as warranted, and we are encouraging the BWR owners group to take the initiative to address the potential issues and get out ahead of us.

We are also considering the potential for further actions. So that is very up front. We're just getting into it type situation. Don't know how it's going to turn out. Don't know whether it warrants additional actions, but we are starting to take actions to figure it out.

CHAIRMAN BANERJEE: Which is in line with what's happening in some other countries as well.

MR. SCOTT: I believe that is true, yes, and whenever we meet with a foreign regulator, you know, their question is, "Well, so how does this impact BWRs?"

We'd really like to get out of the mode that we've been in of, okay, let's do Ps. Okay. Good. Let's do Bs. Let's do Ps. Let's do Bs.

We'd really like to achieve a state of either common treatment as applicable to the two reactor types or an understanding of why there really should going forward be a disparity, a perfectly good reason.

And so the way that the document that we sent to Research was stated was in terms of let's attempt to identify the disparities and whether we should do anything with those disparities to try to get to one regulatory state for both reactor types.

But of course, as I've said and as you've said, you know, every time we look at something new on this issue, we get a surprise. So i don't know how all of that is going to play out.

DR. WALLIS: You mentioned the word "international." Now, this is a universal problem. The French have one approach to it and the Germans another. Have you folks learned anything from what's been going on in these other countries about the GSI 191?

MR. SCOTT: We have learned some

information. We've learned from the French. We've learned some information from the Germans. Many of the countries, quite frankly, come to us and they're behind where we are, and so the flow of information -- they don't have the budget that we have. I mean, you referred to research. The NRC has spent a lot of money on research for this issue, and most regulators in other countries are not resourced to do that.

So I would not say that we have gotten a treasure trove of information from abroad, but we have learned some things, and we've interacted with the Koreans, the Japanese, the Taiwanese, the French, the Germans, and the Spanish since I've been here two years.

DR. WALLIS: Can you give an example of anything that you've learned which had some effect and what it was?

MR. SCOTT: Do you have anything, Paul?

MR. KLEIN: I think we learned from the French their approach to thermodynamic modeling and the results.

DR. WALLIS: Is this the chemical?

MR. KLEIN: Yes, the chemical effect phenomena. I think we're also looking forward to talking to the Japanese in a few weeks here. They have done testing similar to ICET, but with the ability to measure head loss at the same time on a side loop. So we think there will be some interesting information that's exchanged there as well.

DR. WALLIS: Did you learn anything about back-flushing, for instance?

MR. SCOTT: I don't recall back-flushing having been the subject of an international meeting.

DR. WALLIS: I mean, if you can back-flush the screen and if the debris falls off and if that cures the problem, that's a wonderful thing, isn't it?

MR. SCOTT: It is, yes, if that's true. Yes, and one plant at least that we are reviewing at one of our plants has come forward and indicated that they have back-flush capability. The question is how you take credit for it, and you get into regulatory treatment of the system, and we're trying to sort that out even as we speak.

And that's actually an interesting point. I talked about moving insulation as a possible path forward for a plant that can't show a satisfactory but still conservative test result. Another possibility, and we've said all along that this is another possibility, is a back-flush capability. Some have it; some don't.

DR. KRESS: That back-flushing doesn't necessarily fix the issues of the downstream effects.

MR. SCOTT: Yeah, and it could actually aggravate them because you knock the stuff off and now you have clean strainer and you could actually send it through, but remember as we've said, conservative assumptions are made about what gets through.

CHAIRMAN BANERJEE: And also, if that mat falls off in a region where it can erode due to the flow, then you slowly stop to erode the back-flush mat that has fallen down.

MR. SCOTT: You erode the what? I'm sorry.

CHAIRMAN BANERJEE: The mat, the fiber mat that has fallen off.

MR. SCOTT: Okay.

CHAIRMAN BANERJEE: So imagine you back-flush and it falls off.

MR. SCOTT: Right.

CHAIRMAN BANERJEE: It's in a high flow region. The nit starts to erode.

MR. SCOTT: It's going to come back.

CHAIRMAN BANERJEE: It comes back. It's not obvious that it stays there, and it comes back slowly.

MR. SCOTT: Yeah. You get a kind of a saw tooth as far as your head loss goes, but that keeps the core cool.

CHAIRMAN BANERJEE: Yeah, it keeps the core cool, but eventually it can also et into the core. Part of the problem, I guess is that the Germans have found that a lot of fibrous stuff gets held up on the spacers, not at the inlet.

MR. SCOTT: Well, again, we're going to talk to you about what we have observed on that, and Westinghouse is going to talk about it.

CHAIRMAN BANERJEE: So we look forward to experiments that you guys have done on this

MR. SCOTT: Experiments, hum. I wouldn't put it exactly that way, but okay.

CHAIRMAN BANERJEE: I see a lot of --

MR. SCOTT: Again, I would suggest you defer that till --

CHAIRMAN BANERJEE: Anyway, yeah, we'll defer that.

MR. SCOTT: Okay. Wrapping up, conclusions. Our licensees have made substantial progress in reducing vulnerability to strainer clogging and related issues, and we acknowledge that, and we think the industry did the right thing in that area.

There is more work to do because you actually have to do two things. You modify your plan as needed, and you show that your modifications are sufficient to address the issue, and that has not necessarily been done yet.

I say "necessarily" because, again, several plants have stated that they are complete. We have to verify that, and we still have testing issues that could impact that decision.

DR. WALLIS: So everything would seem to depend on how hard it is to resolve these questions.

MR. SCOTT: Of course.

DR. WALLIS: And we don't really know what they are, do we? Well, we don't know. You know.

MR. SCOTT: Don't know what the questions are?

DR. WALLIS: We don't know what these questions are.

MR. SCOTT: Well, I've talked to you about some of them. For example --

DR. WALLIS: Some of them in the past.

MR. SCOTT: Yes.

DR. WALLIS: All right.

MR. SCOTT: But, you know, a lot of the

issues that -- quite honestly, a lot of the issues that staff has raised with the vendors have been the same issues or similar to the ones you all raised --

DR. WALLIS: That's right.

MR. SCOTT: -- last May, and we're not -- you know, we've heard you, and you all came up with some concerns, and we've carried those forward, and we've had some of our own. So --

DR. WALLIS: So the question would be whether there are some questions which are so tough to resolve that you might want to take another path. We don't know if that's the case.

MR. SCOTT: Stated another way, if a licensee cannot show an adequate and conservative test, then they will have to find another --

DR. WALLIS: They'll have to do something else.

MR. SCOTT: Yes.

DR. WALLIS: Okay. Is it your sense that there are some questions like that which are so tough to resolve that they'll have to do something else?

MR. SCOTT: It's hard to say at this point. I don't know whether you'd say that the questions are so hard. The problem is, as I mentioned earlier, that you can heap conservatism on conservatism and end up with a result that you can't live with, and so if that's the case, then you have to either remove some of the conservatisms, which can be tricky, or make some kind of physical change. That's the challenge.

DR. WALLIS: Okay. So you can't assess for me how easy it is to resolve these questions which are still unresolved?

MR. SCOTT: I can tell you that if you have a high fiber plant and you're using a very conservative protocol, you can have trouble showing that you don't have a high head loss.

CHAIRMAN BANERJEE: Does it make any difference if you have buffer or ont?

MR. SCOTT: Buffer has --

CHAIRMAN BANERJEE: Or what kind of buffer you have?

MR. SCOTT: Buffer has an impact, clearly, depending on what the chemical species, you know, what the other materials are that are in containment. We have provided guidance, and I guess we'd say we have provided a review of industry guidance on how to consider whether to make a change to buffer, right, Paul?

So that's out there. Some plants have

availed themselves of a buffer change. I wouldn't say many. Maybe half a dozen, something like that. It's very, very plant specific.

CHAIRMAN BANERJEE: Mike, I'm going to thank you now since you're going to come back in July. We are going to talk to you at length of course, and we'll decide well before the meeting, I think, how we want to organize it, how long it should be and what topics we should cover.

MR. SCOTT: That's fine, especially if you want industry participation.

CHAIRMAN BANERJEE: Right. I think we should do this well in advance if we want that, and so I'm going to just thank you and go on now for 15 minutes.

My watch, I don't have a clock here, says five to ten. Is that correct? So we'll take a break till ten past ten, a 15-minute break.

And thanks once again.

MR. SCOTT: Thank you.

CHAIRMAN BANERJEE: See you later.

(Whereupon, the foregoing matter went off the record at 9:58 a.m. and went back on the record at 10:15 a.m.)

CHAIRMAN BANERJEE: We're going to start

again, and this time we're going to have -- who's going to leave off? Is it you Mo?

MR. DINGLER: Yeah, I'm going to lead off and then give it to Tim.

CHAIRMAN BANERJEE: Okay. So we're going to hear from the PWR Owners Group now and Mo will lead of and then turn it over if you like.

You've got all the time till lunch. Do you have time --

MR. DINGLER: Put us under pressure, you know. Everybody is going to get hungry. So we appreciate that.

CHAIRMAN BANERJEE: Right, and then I think you have a continuation after lunch, too

MR. DINGLER: Unfortunately, you've worked the schedule so that we couldn't be under that gun there.

CHAIRMAN BANERJEE: Right. All right. So go for it. Thanks.

MR. DINGLER: I want to do a little introduction remarks. A lot of discussion now hat the industry is doing we had with Mike, some of the issues, some of the I'll put it in quotes "struggles" that we're having in doing our testing and that, a lot of discussion on bypass testing.

What we're seeing, and I'll give you a little summary of what some of the plants have seen. I've watched a couple tests. I've got the ability to go to near Boston when there was ten inches of snow twice in two weeks. I know the staff got a choice of going to Boston with ten inches of snow or going to Juno Beach, Florida, and they came to Boston. So I appreciate that.

DR. WALLIS: I'll tell you. When you get two feet of snow, you know what debris looks like.

MR. DINGLER: Yeah, you're right there.

(Laughter.)

MR. DINGLER: It was beautiful snow, I'll admit, snow coming down. I'm from Kansas and I saw snow. It wasn't blowing at least. That was the good point of the Boston area.

But what we saw in the bypass testing, and we've got a lot of discussion on that, is we're recommending utilities when they do some testing take fiber only bypass testing and particulate only bypass testing, which gives you an idea what passes through the sump screen.

What we're seeing in some of the stuff that's testing is we're taking tests over a period of time through the whole test. A certain amount of turnover, a certain amount of time period between that, and then we're using SEMs and actually counting and measuring the length of the fiber that went through the sump screen.

What we're seeing, and Ralph has a jar of the water that came through on one of them that we'll show you later, but very small amounts, very small in length of fiber. So that's the key to the discussion that we have going on that Tim will give on our core blockage and stuff like that.

We used to do the prototype testing that we're taking some credit for, they used a sump screen that's called an active sump screen that no vendor had just pointed or no utility is going to put in; forced long fibers through the sump screen, which is not typical of what we're seeing coming through our passive sump screens. But we're seeing some of these areas in small micron size lengths on that.

Particulate, you had some discussion on particulate. I know one utility -- I'll speak for Wolf Creek -- we did particulate only testing to see what kind of particulate, the amount of particulate got through the sump screen also, and then we also then run bypass testing when we put the fiber and particulate in together. So we ran three types of bypass type testing over --

DR. WALLIS: Since the fiber length is so important, it would seem that then you have to be sure that you know how to predict it.

MR. DINGLER: What we did was we put in long fibers. We put in what we feel --

DR. WALLIS: I'm thinking of when you have a jet of steam and water breaking out fiberglass. What is the distribution of fiber lengths that's created, which seems to be an important question in regard to bypass.

MR. DINGLER: Right, and what we --

DR. WALLIS: If it creates all small fibers then they'll all go through.

MR. DINGLER: There's a distribution that was approved by the staff and with the industry coming up with the guidance, and the particulate and fiber is broken up into four to five categorizations, fines, smalls, large pieces, and then intact blankets.

And when you look at that, the preparation of some of those fines and smalls, one protocol was for testing. We put that fines through a blender. Instead of making martinis we made very small pieces of fines. The smallest we put through a leaf shredder.

So there's protocols of how to make sure, Graham or Dr. Wallis, that we got some of that distribution that came out.

So those are some of the stuff that we got --

DR. WALLIS: So then the staff has decided that they know what happens in an accident in terms of the generation of fiber lengths?

MR. DINGLER: Based on the testing that the boilers did and the testing that some utilities did, we're predicting the length of the fibers.

Well, can I speak for the staff? I'm not going to speak for the staff and what they have concluded on that.

MR. LANDRY: Graham, we have had to at some point make an agreement that at some point this is the fibers content that we're going to accept because there's just too many possible permutations and combinations that you could get.

But for the testing that the vendors have been doing for the licensees, we have had to make a decision that, okay, we'll accept this fibrous content as representative.

Does that answer your question?

DR. WALLIS: So you have established the

regulatory space.

MR. LANDRY: Well, we've established what we are willing to accept as a fibrous content because we have to settle on something so that we can move forward.

DR. WALLIS: Right, right. I realize that.

CHAIRMAN BANERJEE: But what do you feel about the experimental database that backs up that, let's say, representative mix of whatever you're going to use? Is there good data to support that?

MR. KLEIN: Unfortunately, the debris generation -- Lee Rigeur (phonetic) is not here at this point. I know there has been testing done where different insulation materials have been destroyed and the debris characterized with respect to amounts of different sizes, but I can't speak to the details.

CHAIRMAN BANERJEE: I wasn't even an ACRS consultant at the time when you guys decided to review this. So maybe Graham was and Tom Kress certainly was.

Do you recall what sort of experimental database there was for the guidance that was given in terms of were there good experiments done?

MR. SCOTT: Let me see if I can rephrase

the question. You're interested in finding out the basis for the staff's conclusions regarding the assumed distribution of fiber sites, yes?

CHAIRMAN BANERJEE: Right.

MR. SCOTT: I'll see if I can get you an answer some time today on that. How's that?

CHAIRMAN BANERJEE: Okay.

DR. KRESS: There were tests where they impacted fibrous materials with the blow-down light materials and measure it. That --

MR. SCOTT: I'm sorry?

DR. KRESS: And measured the actual resulting site. I don't recall who did those tests.

MR. LANDRY: Some of these tests go back 30 years. There was a long test series that was run by Owens Corning on what they called a trademark name, the NUKON, N-U-K-O-N, fiberglass material back in the '70s, and the staff reviewed that fibrous debris content.

I believe the SE was written in 1979, but that I'm going to refer to for other purposes today, and the Owners Group is going to refer to some of that test work for other purposes also.

But some of this database of debris content and sizing goes all the way back into the

'70s. So there is a big database, but it --

DR. WALLIS: So fiberglass which has been wrapped around a pipe or a steam generator for 30 years breaks up the same as fiberglass that Owens Corning tested 30 years ago?

MR. LANDRY: Well, it's going to probably break up a little differently. One of the discussions that we've had with our foreign partners in other areas have concerned material like mineral wool, which isn't in common use in the United States, but does age with heat and radiation, and other countries have used heavily as fiberglass is used in this country because they don't see the aging occurring with fiberglass that they see with materials like mineral wool.

So there might be changes, but there aren't the kind of changes with fiberglass that we see with other insulating materials, which we are glad are not in heavy use in this country.

CHAIRMAN BANERJEE: But there would be also changes in the binder and stuff, right?

DR. WALLIS: Binding is driven off, I understand.

MR. LANDRY: Yes, but we'll have to get more information on the --

MR. DINGLER: Well, I can speak for the

binder. The binder is based on the heat of the pipe is evaporated over a period of time. So you have very little binder left at that point right close to the pipe, and then as you further get out, depending on the thickness, you have some binder staying and some that gives thickness of your insulation and how hot the pipe is.

DR. WALLIS: The fiberglass though that are removed from the back of my stove after being used for some years is much more crumbly than the stuff which is new. Is that not the case with nuclear material?

MR. ANDREYCHEK: Much of the fiberglass that's used is in a blanket type material, and that is a woven mesh material that has been impregnated with an epoxy or some sort of material to keep it semi-impermeable.

So the fiberglass is already in a container that's wrapped around the piping in most instances. I can't speak for --

DR. WALLIS: This protects it from oxidation or whatever it is. I don't know what it is that changes its properties.

MR. ANDREYCHEK: It also makes it easier to put on and take off in that there's typically something along the lines of something to hold the pieces together so that you wrap it around the pipe and fasten it.

So that's another benefit to the NUKON system that was tested, and even the test that Dr. Landry referred to was testing the NUKON in a pillow type configuration that already was in a container.

CHAIRMAN BANERJEE: Why don't we just table this question? You're going to get asked information, Mike, right?

MR. SCOTT: I've asked for the staff person who is knowledgeable about the retransport to come over. I guess the right time to answer the questions would be when the staff talks this afternoon, right?

CHAIRMAN BANERJEE: Yes, let's do it then.

MR. SCOTT: Okay.

CHAIRMAN BANERJEE: Okay. Let's move on.

MR. DINGLER: I'm going to turn it over to Tim, and then we'll go through our presentation on that.

MR. ANDREYCHEK: Thank you, Mo.

My name is Tim Andreychek. I work for Westinghouse, and I've been supporting the Owners Group.

There was addressed a question that the ACRS Committee asked earlier. I've been involved in containment sump work since 1983, starting with USAA-43, and specifically with this issue since 1997, starting with Generic Letter 97-04 and just prior to that. So I think the industry and particularly the Owners Group has recognized the need to have continuity, and I just wanted to lay that out on the table.

CHAIRMAN BANERJEE: Tim, where are you? Do you have lab facilities where you are?

MR. ANDREYCHEK: We have some lab facilities. We also subcontract out to other lab facilities to do work, as appropriate.

CHAIRMAN BANERJEE: Okay. So you have your own lab facilities.

MR. ANDREYCHEK: We have some lab facilities, not as much as we used to have back in the '70s. Yes, we have lab facilities.

CHAIRMAN BANERJEE: Okay. Go ahead.

MR. ANDREYCHEK: Thank you.

With regard to today's presentation, it's on WCAP-16793-NP. The NP stands for non-proprietary, and the title is "Valuation of Long-term Core Cooling Considering Particulate Fibrous" --

DR. WALLIS: I always thought it meant nuclear power. It means non-proprietary.

(Laughter.)

MR. ANDREYCHEK: No, non-proprietary.

DR. WALLIS: So that explains why the N is sometimes missing.

MR. ANDREYCHEK: That's correct.

MR. SCOTT: All of these years you've wondered about that, haven't you?

(Laughter.)

DR. WALLIS: Well, the simplest things always baffle the experts, you know.

MR. ANDREYCHEK: -- "in Particulate, Fibrous and Chemical Debris in the Recirculating Fluid."

And on Slide 2, the objective of this particular program was to demonstrate sufficient long-term core cooling is achieved for PWRs to satisfy the requirements of 10 CFR 5046 with the bypass debris and chemical products that might be transported to the reactor vessel and core by the recirculating fluid from the containment sump and through the sump screen.

And the criteria specifically we're looking at the dressing or removal decay heat and maintaining a coolable core geometry.

Next slide, please.

It's important to note that the results of this program apply to the fleet of PWRs regardless of the design, whether it be a B&W design, a Combustion Engineering design, or any of the Westinghouse designs, and we have in the audience with us representatives who have worked with us on this WCAP-4 from Areva, Gordon Wissinger, and I'd like to recognize him.

Next slide, please.

CHAIRMAN BANERJEE: Are you going to very briefly describe any differences in these designs which can actually have an effect on the downstream effect?

MR. ANDREYCHEK: That's not a specific part of the presentation, but we can certainly talk about some of the differences in the design features.

Specifically, one design feature that we do call out and is included in the presentation is the upper plenum injection of two-loop PWRs that are unique to Westinghouse, but in terms of other design features, fundamentally the ECCS system tends to work in the same way. The flow rates may be a little different, but that's really not what governs or drives the downstream effects that we're looking at in the core.

What really drives the downstream effects in the core is what is the bypass. What's the debris mix that you have and what gets to the screen? So the design of the NSSS system is really a secondary item, with the exception of upper plenum injection, which is discussed in this presentation specifically.

CHAIRMAN BANERJEE: Okay. Go ahead.

MR. ANDREYCHEK: I don't know if you had the opportunity to review the WCAP, but I just wanted to make sure that you are aware the WCAP is out there, and for the purposes of completeness, we've identified the draft safety evaluation that we've received for review and the ADAMS number.

Next slide, please.

DR. WALLIS: Actually we saw it last year because it came out in May.

MR. ANDREYCHEK: It came out in May of last year. That's correct.

CHAIRMAN BANERJEE: Did we have any comments last year?

DR. WALLIS: Well, I was all tuned up to give comments, but the Subcommittee never met on the issue.

CHAIRMAN BANERJEE: So now you have a

chance.

DR. WALLIS: I have to remember what I was going to ask.

MR. ANDREYCHEK: With regards to comments, we have received two rounds of RAIs from the NRC. We have responded to them, and --

CHAIRMAN BANERJEE: We don't have, Ralph or Mike, the RAIs and the responses. We have the WCAP. We have the SE, and we have the terms and conditions or whatever, conditions.

MR. SCOTT: I did not send the RAIs or the responses over to you. Of course the conditions and limitations reflect the results of that review, but if you would like those, we can certainly provide them.

CHAIRMAN BANERJEE: It would be useful, I think, to have them.

MR. SCOTT: Okay. You'd like to see the RAIs and the RAI responses.

CHAIRMAN BANERJEE: Yes.

MR. SCOTT: Okay.

MR. LANDRY: We asked in those two rounds something like 80 or more than 80 RAIs. So it's formidable material.

CHAIRMAN BANERJEE: Right, but you know,

sometimes in the documents we have you refer to the RAIs and the responses, and we didn't see that, but I think that's just something that we can get and look at before the full Committee.

MR. SCOTT: And that's fine, and we'll get that to you.

One thing to bear in mind is that one issue has arisen regarding an inconsistency in some assumed values for, I believe, thermal conductivity, right? Of the material?

CHAIRMAN BANERJEE: You use something like .1 in most of the --

MR. SCOTT: Right. There was an inconsistency in the -- say again. Clarification is needed, and that will not be reflected yet because Westinghouse has not responded to it, but obviously that will have to happen before the final SE. We don't consider it a significant issue, but it needs to be clarified, and if you happen to note the inconsistency, I'm just telling you you won't see it resolved in those RAI responses.

CHAIRMAN BANERJEE: Okay.

MR. ANDREYCHEK: With regards to the topics we're looking at, we have approached it from an integrated fashion, i.e., you can take a look at any one of these particular items and you might consider that not fully satisfying the requirements for demonstrating long-term core cooling. When taken collectively, we believe they do, and we state that.

CHAIRMAN BANERJEE: I have a question about the core inlet designs between the different plants that you showed in the previous slide.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: Are there any significant differences in the core inlet design?

MR. ANDREYCHEK: Each of the core inlet designs that are used in current plants have features associated with them to collect debris. Now, the specific implementation of a design, there may be some variation in those. However, they all perform and behave in a very similar manner, that is, that they have a reduction or they put obstacles in the flow into the core for the purposes of collecting and trapping debris under normal operating conditions to avoid wear and fretting of other materials that might get into the core with the high velocities that you would expect to see during normal operating conditions.

They behave in a similar way post accident to collect potentially debris that's transported into the screen.

So with regard to I'm going to call it a functional requirement, functional performance behavior, the functional behavior and functional performance is the same regardless of the design. So the implementation of specific design features may be a little different.

CHAIRMAN BANERJEE: It would be useful to at least see one of these designs. I was looking for it in your document.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: I was looking for a diagram or picture or something of the core inlet and a spacer and a support plate, and nothing was there.

MR. ANDREYCHEK: Okay. We do have some spacers, spacer grids in this particular diagram, at least on the bottom nozzle and up a couple of spacer grids. We may not have perhaps as much detail as you'd like to see, but let's take that under advisement.

CHAIRMAN BANERJEE: Okay.

DR. WALLIS: Tim, could I ask about this integrated matter? I didn't see much in the way of experiment or experimental evidence. I saw a lot of assertions, such as the build-up is naturally limited to half the grid span, and smaller particulates will regularly pass through the grid structures, but these are just assertions in the absence of experimental evidence.

And I just wondered if your integrated manner that you talk about here involves testing these assertions experimentally or if you just make them.

MR. ANDREYCHEK: There is some experimental data that I'll present to you later.

DR. WALLIS: Are you going to show us that? That will be very helpful to me because it may well be true, what you say, but without some kind of back-up evidence, I'm left wondering should I believe it or not.

MR. ANDREYCHEK: I understand. The other thing I would offer -- pardon?

CHAIRMAN BANERJEE: In the core inlet, I mean, what sort of holes are there?

MR. ANDREYCHEK: Bear with me just a second and I'll respond to that question, but I also believe that Ralph Landry has some photographs that he will show.

CHAIRMAN BANERJEE: Okay. If you will show that, that would be very useful.

MR. ANDREYCHEK: As well as photographs of a particular test where there was some debris that was added to the bottom of a simulated core plate and how it worked in terms of trapping the debris.

With regards to dimensions, typically the dimensions you would expect to see through the most restrictive areas at the core inlet are on the order of approximately .05, .06 inches, maybe as much as .09 inches in the debris capturing features of fuels.

CHAIRMAN BANERJEE: They're smaller than at least nominal hole size that you have in the screen, which are about .1 inches.

MR. ANDREYCHEK: The screen size dimensions are .1 inches and sometimes smaller. I believe Wolf Creek is a little less than that.

MR. DINGLER: We're less than that. I think we've got the smallest.

MR. SCOTT: Some of them, I believe, are about .08.

MR. DINGLER: Yeah, .08. So right now the screeners or strainers are supposed to have the smallest opening in the PO or anything else downstream. So where they take exception to that requirement, it's in the NUREG or in the reg. guide. I'm sorry.

CHAIRMAN BANERJEE: Let me understand

this. Typically, nominally the sump screens have an order of .08 to .1, maybe a little larger, but there's a range of these. And the smallest openings in the core region are .05?

MR. ANDREYCHEK: Typically those are in the debris capturing filters' features at the bottom of the fuel. In the open portions of the fuel, in the spacer grids, they could be upwards of .115 or so mils.

If you're looking straight at a fuel assembly where you have a dimple or a sprain contacting the hole, the fuel rod in place might be on the order of about 40 mils. And if you look at normal operating conditions, typically if you are looking at crud deposits, that's typically where you'd expect to see some crud deposits, right at the location where the dimple and spring is at.

CHAIRMAN BANERJEE: Okay. Go ahead.

MR. ANDREYCHEK: Okay. So what we looked at, we looked at three general areas, blockage of the core inlet, whether it be the top or the bottom; collection of debris on fuel grids; collection and deposition of material on the fuel cladding proper; and when considered in total, the criteria of 10 CFR 5046 are satisfied, and that's what we demonstrate in the WCAP.

Next slide, please.

Before we can move on and before we did much work we spent some time developing a long-term core cooling success criteria, as it were, and the criteria was we were to be successful if we limited the maximum clad temperature to 800 degrees Fahrenheit.

DR. WALLIS: Now, is this the average temperature? Because somewhere in your report you talk about hot spots being allowed to go to 2,200.

MR. ANDREYCHEK: That was addressed in an RAI, and that was something that we had done early that has found its way into the report. That will be removed in the final report.

DR. WALLIS: Oh, so that has been corrected.

MR. ANDREYCHEK: Yes.

DR. WALLIS: I wasn't aware of that.

MR. ANDREYCHEK: That's correct.

CHAIRMAN BANERJEE: How hot can hot spots get, and what how large can a hot spot be?

MR. ANDREYCHEK: If you will allow me, if you would, let me get a little further in the presentation and I think we can address that in some of the calculations that we've done based on build-up of debris on fuel cladding, and I think we can demonstrate that the hot spots are under 800 degrees Fahrenheit.

DR. WALLIS: So this 800 is everywhere now?

MR. ANDREYCHEK: It is everywhere, but we --

CHAIRMAN BANERJEE: Including hot spots.

MR. ANDREYCHEK: Including hot spots, that's correct.

CHAIRMAN BANERJEE: And that was established on the basis of what?

MR. ANDREYCHEK: If you'll allow me to get to the next slide, I will address that.

CHAIRMAN BANERJEE: Okay.

MR. ANDREYCHEK: The second criteria is that the cladding, the thickness of the cladding oxide in fuel deposits are less than an average of 50 mils in any given fuel region that we were looking at, and that is per rod.

DR. WALLIS: So what is this averaged over? Could it be .1 in some parts and zero in other parts? What's it averaged over?

MR. ANDREYCHEK: It's over the size of the node or the core that we're looking at. We're looking at the various nodes in the core and --

DR. WALLIS: Is it between spacers or something, between grids maybe?

MR. ANDREYCHEK: It's actually between rods. And the reason we have it between rods is that typically you have approximately a 100 mil gap between rods. So we wanted to make sure that we didn't get rod-to-rod bridging of the deposits, and again, the reason that I say it's over regions is you have different elevations we looked at. So we're looking at the deposition at any given elevation that we've modeled, and that's the region that we're looking at, and that's the reason we have the terminology the way it is.

DR. WALLIS: So the gap between rods is typically .1 of an inch?

MR. ANDREYCHEK: Approximately.

DR. WALLIS: So these two thicknesses of .05 would fill the gap?

MR. ANDREYCHEK: Potentially, yes.

DR. WALLIS: And then we would presumably trap anything that we coming through like fibers or particles?

MR. ANDREYCHEK: Potentially, yes. That's why we're less than that.

DR. WALLIS: But suppose it were .049. Wouldn't that be just as bad?

MR. ANDREYCHEK: Actually what we found in doing the calculations that we've done so far is that we're somewhere limited around approximately ten to the 12 mils. We haven't seen anything that's really been highly developed. The 50 mils, again, is a criteria that says we don't want to get any further than that, and the actual evaluations we've done to date have been generally less, much less than that. On the order of around 11 to 12 mils.

CHAIRMAN BANERJEE: Go ahead.

MR. ANDREYCHEK: Okay. The criteria that we've identified here are applicable after the initial quench of the core, and certainly before or after the recirculation phase because prior to the recirculation there is no debris in the pump fluid. You're injecting water from either the refueling water storage tank or the borated water storage tank which is cleaned, and you don't have the debris that you have in the sump. There's no chemical products that you're introducing to the core.

So these apply once you go into recirculation from the sump. It's consistent with the long-term core cooling requirements of 10 CFR 5046(b)(4) and (b)(5) and provide for demonstrating LOCA temperatures in the core, stable and continuously decreasing, and the debris entrainment in the cooling water will not affect the heat removal.

These criteria are designed for GSI-191. They are not intended to present new or additional long-term core cooling requirements above and beyond what's already listed in 10 CFR 5046. This is our interpretation of how we would make that.

DR. WALLIS: I think that you're concluding that as long as you supply the boil-off quantities, it doesn't matter. The core is just the pool of water cooling you off, and it doesn't matter how this water gets in. I think that's what you're going to tell us.

Is that a fair statement?

MR. ANDREYCHEK: I would not characterize it strictly as that.

DR. WALLIS: If it just came in through the hot assembly, it then spreads through the whole core.

MR. ANDREYCHEK: We have demonstrated that by calculating --

DR. WALLIS: So it could get in anywhere.

It could come in from the side or somewhere.

MR. ANDREYCHEK: That is correct.

DR. WALLIS: As long as it replenishes the boil-off.

MR. ANDREYCHEK: It will maintain core cooling, yes.

DR. WALLIS: Have you tried to block the whole thing?

MR. ANDREYCHEK: Actually I have done that calculation back in 2000, 2001, where we did look at flow through the side of the baffle barrel region, and these were done internal. It was a parametric study I wanted to see, and we did demonstrate looking at a number of fuel rods, seven or eight fuel assemblies, and actually replaced the hot assembly in the middle. We did get water through.

DR. WALLIS: Into the middle?

MR. ANDREYCHEK: Into the middle, and we maintained acceptable core cladding temperatures of well under 800 degrees Fahrenheit. We were not looking at debris deposition at the time, but we were able to maintain clad temperatures on the --

DR. WALLIS: It might be good to throw that into the evidence pile if it's still available.

MR. ANDREYCHEK: I'd have to look at it,

to be honest.

MR. DINGLER: There's a terms and conditions that allows utilities to use that method if so needed on there.

MR. ANDREYCHEK: Okay. Next slide, please.

Okay. Getting back to the basis of 800 degree temperature selected based on autoclave data, it demonstrated oxidation and hydrogen pickup to be well behaved at and below 800 degrees Fahrenheit temperature and the reduction or oxidation of the cladding is very small at that point in time. For all practical purposes it was negligible cladding oxidation that was noted at temperature os 800 degrees F. and less.

CHAIRMAN BANERJEE: And these were at typical conditions that might occur in terms of hydrogen concentrations and things?

MR. ANDREYCHEK: I'm going to defer to Art Byers on that.

Art, was that testing that you had done?

MR. BYERS: Art Byers.

CHAIRMAN BANERJEE: You'll have to come to the mic.

MR. BYERS: Art Byers of Westinghouse.

And these 800 degree tests were primarily done in steam, high purity steam.

CHAIRMAN BANERJEE: And the hydrogen concentrations were typical of what you'd find in the core?

MR. BYERS: In those tests the hydrogen was not controlled beyond what the equilibrium hydrogen would be.

CHAIRMAN BANERJEE: Would you expect there to be any effect due to the radiolysis effect and things like that?

MR. BYERS: I think that they would be very small.

CHAIRMAN BANERJEE: Okay.

DR. WALLIS: But hydrogen would affect the embrittlement, wouldn't it?

MR. ANDREYCHEK: If you pick up hydrogen content, you would affect the embrittlement, and that's the reasons we were looking at maintaining.

We did notice that at temperatures above 800 degrees F. you did pick up hydrogen. You did pick up oxidation. Below that we did not.

If the ECCS system is working as it should, I would not expect to see a major increase in hydrogen concentration in the core.

DR. WALLIS: Actually your temperatures

are significantly below 800 anyway, aren't they?

MR. ANDREYCHEK: At the time recirculation is initiated from the sump, that's exactly correct. Typically the peak clad temperature anywhere in the core at the time of recirculation is on the order of approximately 270 degrees Fahrenheit because we have recovered the core. It's 20 or so minutes into the accident. We do not expect to see much in the way of hydrogen at that point in time. We believe that the steam tests are representative of what you'd expect to see in the core at that point in time, assuming that you don't get into a severe accident condition where you might expect to see more hydrogen.

And, again, the 50 mil limit on the oxide plus deposits was selected to -- I didn't do that.

The 50 mil limit was selected to preclude formation of deposits that would bridge spaces between adjacent rods and block flow between fuel channels.

DR. KRESS: Is this new autoclave data that you've done?

MR. ANDREYCHEK: I wouldn't say that it's new. It has been around for a while, and in fact, that data was shared with NRC by both Westinghouse and Areva in the respective offices, and it was reviewed by the NRC fuels folks to take a look at, and any questions they had about the way the test was run were addressed either there on the spot or in subsequent communications.

DR. KRESS: Do the results follow the Cathcart-Powell Arehnius line or the same mode?

MR. ANDREYCHEK: You know, again, I can't speak to that because I've not been directly involved in those tests, but my understanding is that the results were as expected.

DR. KRESS: That would be the expected. That's where you would get the expected value.

MR. LANDRY: When we looked at the test results, we on the staff imposed the 800 degree limit based on the available data that this was cladding that had been heated to a high temperature, quenched, and then reheated to 800 degrees. We said that the limit was 800 degrees and you could not take it back to 2,200 again because there was on data beyond this second reheat 800.

DR. KRESS: You don't know what it did to the embrittlement.

DR. LANDRY: The clad ductility was demonstrated through recompression tests on autoclave material that had been heated, quenched, and then reheated to 800, and we said if the Owners Group wanted to take the cladding beyond 800, they had to do the autoclave testing, and again show that they could maintain ductility for a temperature beyond this second heat-up of 800.

Now, you have to keep in mind this is a second heat-up.

DR. KRESS: It's not like the original.

DR. LANDRY: This is not the first heat-up. This is a second heat-up, and we said, okay, the second heat-up can only go to 800 because you don't have data.

We don't know how far it could be taken, but we do know it could be taken to 800.

CHAIRMAN BANERJEE: How long were these tests for?

MR. ANDREYCHEK: The 800 degree temperatures were on the order of 30 days or so, extended periods of time. This was not a, you know, four or five hours test.

CHAIRMAN BANERJEE: Right. Because obviously the time matters in this probably.

MR. ANDREYCHEK: Again, for the 30-day time period or so that these tests were run, we saw a negligible change in the material properties in the steam environment at 800 degrees, up to 800 degrees

Fahrenheit, and these were run at several different temperature levels along the way.

MEMBER ABDEL-KHALIK: What is the oxide layer thickness corresponding to 17 percent oxidation for the initial heat-up?

MR. ANDREYCHEK: Well, that depends obviously on the thickness of the cladding material that you have, and that's, you know, fuel design specific. There are specific numbers that are recommended in the WCAP, and I don't have those right at my fingertips, but we've also talked about those in RAIs, and you will get the opportunity to take a look at those.

DR. LANDRY: For the thin-called cladding, it can be down to 120 microns. For the thicker walled cladding, 150 microns.

What I'm going to say this afternoon is showing that what they're doing is in the range of 17 percent oxidation level.

MEMBER ABDEL-KHALIK: So really it's very small compared to the 50 mil limit that you have.

MR. ANDREYCHEK: That is correct. That is correct.

Okay. Next slide, please.

DR. WALLIS: Well, let's go back to this

.050 inch. I think in your analysis you considered particles coming in when you boiled and made these other deposits, particles also get deposited.

WCAP has different chapters on fibers and what happens to chemicals and what happens and so on. It doesn't have much about sort of the synthesis between them where you make an oxide and then this narrow down the passage, which then catches fibers, which then catches particles so that the whole thing, the whole environment is analyzed. So you've got all of these separate analyses on separate effects.

Did you actually look at the synthesis between effects in some way?

MR. ANDREYCHEK: What we have done, and again, unfortunately, you have not seen the RAI responses, the RAIs or the responses; what we have done is adjusted the debris deposition to account for fiber materials that would be passed through the core. So we did address that through a --

DR. WALLIS: So we're at a real disadvantage here. I studied the WCAP, and I had a lot of questions. Apparently they've been answered in material that we do not have.

MR. DINGLER: I think, Dr. Wallis, some of the questions or answers to your is go to Sheet 48 and we'll get there.

DR. WALLIS: Okay.

MR. DINGLER: But we added clad, oxidation, crud and chemical into that item there.

MR. ANDREYCHEK: But you are correct. There is some information that you haven't had the opportunity to take a look at yet unfortunately.

DR. WALLIS: So is there going to be a modified WCAP then?

MR. ANDREYCHEK: Yes, there is.

Okay. If we go to the next slide, please, this is a direct reference to what Dr. Wallis had mentioned earlier. This curve is for a typical large, four-loop Westinghouse PWR. It does show the boil-off rates to match, the flow that would be needed to be provided to match boil-off rates within four hours following postulated large break LOCA. You need approximately 250 gallons per minute of flow, and after 30 hours you're down to approximately 150 gallons per minute flow needed to match boil-off.

CHAIRMAN BANERJEE: Let me ask another questions regarding. Imagine that the level was such that the upper part of the fuel was only in steam, that you had a fairly defined two-phase level during boil-off after 30 hours when it's not that vigorous.

Is the steam flow at those conditions enough to give you good enough heat transfer at the top of the fuel assuming the sort of top peak shapes that you showed?

MR. ANDREYCHEK: I think the answer to that is yes, and again, I'm assuming -- and let me make sure that I understand the question. You're assuming a top skewed power shape profile. So you've got high power shifted to the top.

CHAIRMAN BANERJEE: And you've got your level down so that no liquid is reaching the top. You're only boiling off that whatever it is in the covered region.

MR. ANDREYCHEK: I'm finding that one a little difficult to imagine. It's almost overly constrained.

DR. WALLIS: It looks like TMI, right?

MR. ANDREYCHEK: Yeah, and let me explain why I think that. Basically with the postulated cold led break, the driving head is in the water build-up in the downcomer, and the core region looks like the monometer. So as you reduce the -- go further out on the decay heat curve, the water level is going to want to tend to rise. So the energetic boiling is going to tend to occur higher up into the core. You certainly have some subcool boiling low.

CHAIRMAN BANERJEE: I'm just talking very simple scenario. Imagine you have resistance in the flow. So your monometer has a resistance somewhere, one leg.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: And the top part of it is heated.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: All right? So now you're able to supply a certain amount of water, and it starts to boil so that the level doesn't reach the top now. It reaches halfway up the other leg.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: Now you've got steam flow at the top.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: Where must the level be to reach your 800 degrees at the top? It's a homework problem.

MR. ANDREYCHEK: Fair question. We have not tried to look at that. We've not evaluated that particular scenario. However, I would suggest that there's information available through various programs, experimental programs that have been done in the past to look at various --

CHAIRMAN BANERJEE: I can play with the resistance --

MR. ANDREYCHEK: Sure, you can.

CHAIRMAN BANERJEE: -- until I get such low flow that the level of boil-off will be almost just a little bit above, okay, because you have a certain gravity driving head which has to put it through this.

MR. ANDREYCHEK: Right. We agree.

CHAIRMAN BANERJEE: Eventually if I made 100 percent resistance, there will be nothing going through, right?

DR. WALLIS: When you do your 99.4 percent blockage, don't you get something like this? Because you've got a humongous resistance.

MR. ANDREYCHEK: The bottom.

DR. WALLIS: At the bottom. Doesn't the level drop in the core at all?

MR. ANDREYCHEK: Actually the level does not drop. We demonstrate that the level --

DR. WALLIS: It does not drop.

MR. ANDREYCHEK: And you'll see a plot of that a little bit later.

DR. WALLIS: I remember noticing that. I

was a bit puzzled why it didn't drop.

MR. ANDREYCHEK: And the reason for that --

DR. WALLIS: It seems to have no effect at all.

MR. ANDREYCHEK: Well, the bottom line is what you get through one assembly is more than sufficient with the gravity head. It's more than sufficient to provide for make-up, and while the rate of increase of water might be a little different between the cases, you still increase the mass inventory in the core over time, and we ran --

CHAIRMAN BANERJEE: He answered the question for me. I'll see if you agree. He said if the level drops below half the core, then you've got problems. Is that right?

MR. ANDREYCHEK: Without looking at specific calculations, I can't really comment on it.

CHAIRMAN BANERJEE: In rough terms.

MR. ANDREYCHEK: In rough terms, if I'm well below half of the core, I believe I have a problem, yes.

CHAIRMAN BANERJEE: So if I have a resistance such that the flow of water is sufficient only to give me a level which is sufficient --

(Electrical interference.)

MR. ANDREYCHEK: The question in return for clarification purposes, what would cause that resistance? We demonstrated that we don't see a sufficient build-up of particulates or of debris on the fuel cladding surface or grids to create sufficient head loss that you would get that large of a pressure drop.

CHAIRMAN BANERJEE: Let me reverse the question in a very simple way to you then. You've got holes which are .1 inch roughly speaking in your screen.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: This can give you quite a large pressure loss, obviously, when you get mat or whatever. Give me a typical number for that pressure loss, whatever it is.

MR. ANDREYCHEK: In inches.

CHAIRMAN BANERJEE: Now, imagine that some of this stuff gets through and it gets into the core inlet, and besides, your gap between the fuel is .1 inches.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: About the size of this hole, roughly. So I can imagine the scenario, and there's lots of debris around that it gets in, and it goes into the region of the core inlet and the sides so that now they all look like screens. The holes are about the same size. All right?

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: So now I have this pressure loss, whatever it is.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: Wherever the water goes, it brings with its stuff till it builds up and then you've got a scenario where you have a pressure loss across this screen, if you like, which is now around the core, which is about the same as what you'd get in the screen through which the water is flowing.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: Now, you've only got a gravity head driving this. So the question I'm asking is I'm reversing the question. At what flow rate will you get the level falling below half the core so that the top of the core is now exposed to steam cooling only and the question I asked before is how much steam do you need to keep it below 800 degrees Fahrenheit?

MR. ANDREYCHEK: I don't have that answer for you, and if that's a homework problem, I'll take it.

CHAIRMAN BANERJEE: Yeah. So if you say that, okay, it's going to be a flow which is so low that even if I have a very high blockage and pressure loss it's fine; it's not going to be an issue; then that would be an interesting answer to that.

MR. ANDREYCHEK: Well, let me suggest we can take a look at perhaps going in some direction towards answering that in a table, data that I'm presenting a little later in this presentation.

CHAIRMAN BANERJEE: I notice I've gone through your WCAP, and I didn't see the answer to this question.

MR. ANDREYCHEK: Okay. But in this presentation I think there are some data that might help illuminate that.

CHAIRMAN BANERJEE: Okay.

DR. WALLIS: Could I follow up on that, Tim? And this was my concern, too. Throughout the WCAP as I read it -- I didn't see the RAIs -- I see a statement such as "debris build-up will not become impenetrable." Well, okay, but how much resistance does it create?

That was never addressed in the WCAP. You simply say it won't become impenetrable, but how penetrable or how partly penetrable does it need to be before it creates the kind of problem that my colleague, Dr. Banerjee, is talking about?

That never seemed to be addressed because there's never any prediction of where the debris goes and how much resistance it creates in the WCAP.

CHAIRMAN BANERJEE: Or inversely, how much resistance must there be before you have a problem?

And if you can show that resistance as unrealistic, then okay, but I think it's an interesting point to back calculate that resistance.

DR. LANDRY: Sanjoy, if I can put this in perspective, in some of the vendor tests that the Owners Group did, and I'll talk about the tests this afternoon, which we have problems with for other reasons, they used a prototypical -- and that's the paper I was passing around -- a prototypical core inlet plate, and when they put a large quantity, an extremely large quantity of material in the flow path, captured it on the core inlet, that produced a pressure drop across the core inlet of a third of a psi.

With a normal pressure drop across the core of 60 psi, it says that even with a very large quantity of material captured at the inlet of the core, you're adding very little to the overall pressure drop.

DR. WALLIS: There isn't 60 psi with gravity head in the downcomer.

DR. LANDRY: This is pressure loss across the board.

DR. WALLIS: We're talking about long-term cooling though. You've just got this little gravity head.

CHAIRMAN BANERJEE: And that would depend on the flow rate obviously, but --

DR. LANDRY: I'm just trying to put it into perspective. What kind of pressure loss are we talking about compared to the pressure loss you would get across the --

CHAIRMAN BANERJEE: How much is the sort of allowable pressure loss in some sense in the screens? It depends on the net positive suction head of the pumps and all of that sort of stuff, but typically what is the number there?

DR. LANDRY: Are you talking about the screens? The sump screens?

CHAIRMAN BANERJEE: Sump screens.

DR. LANDRY: I don't do sumps. I only do cores.

CHAIRMAN BANERJEE: Well, maybe one of you could answer that.

DR. LANDRY: I'm a specialist.

CHAIRMAN BANERJEE: Okay. But I'm trying to understand. Imagine that the core screen is acting a little bit like a sump screen.

DR. LANDRY: Now, they did a lot of tests, and that's part of the testing that they've been doing when they did the test at CDI in New Jersey and the other facilities. It's testing, build-up of debris on the screen, and what is the pressure loss across the screen.

CHAIRMAN BANERJEE: Right.

DR. LANDRY: So I don't have those numbers at my fingertips, but I know that they have been sufficient to not inhibit or not interfere with the NPSH requirements of the SI pumps.

CHAIRMAN BANERJEE: Right. Now, I'm going back to the pole sizes. They're typically sort of similar to the sump screens, maybe a little smaller. Their floor area, I don't know what they are, but I imagine it's smaller than what's now being put forward into the sump screens. So I'm think of this a little bit like a sump screen, if you like.

So the pressure losses that you get across sump screens typically would be similar -- I mean, I'm just arguing this in my own mind -- to what you would expect across sump screens of the same open area.

Now, the two numbers that I don't have, what is the open area and the typical hole size in the core screens now, let's call them, as opposed to sump screens. Are they comparable? And should we expect similar pressure losses across them or not? Or should we expect higher pressure losses?

Because we've done a lot of work on sump screens. So we have a pretty good handle on what chemical effects do and all of this other stuff, and therefore, it will just give me a feel for what I might use as a bounding number for that.

That's why I was asking you what pressure losses do we get typically across sump screens.

DR. LANDRY: I think the sheer quantity of material is considerably different between what is captured on the sump screen and what is available to be captured at the core inlet.

CHAIRMAN BANERJEE: Sure, but in the sump screens, as people have said, the worst problem is often with intermediate amounts of debris or very small amounts in some cases.

Do you have an answer?

MR. KLEIN: To try and address the question on what we see in the sump pressure drops, there is no typical number, but the range might be from very little pressure drop to maybe I think 27 feet was a high number.

CHAIRMAN BANERJEE: So what you're really trying to do, of course, is to make screens large enough so that it doesn't challenge the net positive suction head of the pump, assuming that the pressure losses in the rest of the system are fairly small, right?

MR. KLEIN: I think the plant specific designs are very much dependent on the amount of margin they have in their pumps, and so the particular design that's employed by the licensee is affected by, you know, how much margin they have, how much space they may have on their containment floor. So there's a number of different factors that the plant specific debris mixture -- that they have to accommodate.

CHAIRMAN BANERJEE: Sure. So in my own mind after reading this report, this was the question I had. I think of the core as having a screen behind it and think of it as having screens on the side of it, a very simplistic picture.

Now, what sort of open area do I need

there if I draw an analogy with sump screens in order to have a low enough pressure loss that I can get enough water in so that the boil-off level is such that the top of the core doesn't get to 800 degrees in steam cooling?

DR. LANDRY: I think we're going to talk about that, Sanjoy, when we get into the W/COBRA TRAC calculations which the Owners Group performed, and this afternoon I'm going to talk about some trace calculations which we performed.

And the answer is you have to block off. You can block off 95 percent of the core inlet and still maintain adequate core coolant.

CHAIRMAN BANERJEE: Yeah, but --

DR. LANDRY: So that's a considerable amount of blockage that you can sustain, and then you have to put that into perspective of the quantity of debris that's available to do that blockage.

CHAIRMAN BANERJEE: Well, let's see.

DR. LANDRY: What I might do right now, I'll --

MEMBER MAYNARD: But water gets through the screen.

DR. LANDRY: I'm just going to pass something around here. Tim and Mo, one of the two, mentioned I had some water from a screen test, and I'll pass this. I was going to wait for this afternoon, but it sounds like a good time for show and tell now.

I learned in elementary school that show and tell was the best part of the day, and some of my experiments got me extra vacation time, too.

This is water that came through a sump screen, an active strainer, and if you don't shake it up, you'll be able to see the debris on the bottom of the vial. If you shake it up, you won't see anything.

But I'll pass this around right now so that you can get a visualization of exactly what went through one of the active strainers in one of the tests that was performed by the owners.

DR. KRESS: Is the amount compared to the amount of water about right? Is the density --

PARTICIPANT: We didn't dilute it.

DR. KRESS: You didn't dilute it. Yeah. I have a question about the slide you have up here. I presume that's matching the state and heat of vaporization with the decay heat curve, which implies some pressure to me. What pressure is this? Is it atmospheric?

MR. ANDREYCHEK: No, it's typically the

pressure that you would expect to see in the containment at that point in time.

DR. KRESS: Which varies back in time.

MR. ANDREYCHEK: Which varies. This was taken from a specific plant's safety evaluation report.

DR. KRESS: I see.

DR. WALLIS: It's about 260 degrees, isn't it?

MR. ANDREYCHEK: That's correct.

DR. WALLIS: It's almost atmospheric.

DR. KRESS: Almost atmospheric.

MR. ANDREYCHEK: It's close. It's probably about 20 psi.

DR. WALLIS: Did you or staff get access to the material that we saw when we were in Germany, where they had a sump screen test followed by a simulated core assembly?

MR. SCOTT: Very recently Dr. Banerjee sent that to us.

DR. WALLIS: And we saw the debris on the bottom of the core assembly and the grids.

MR. SCOTT: Okay. We got that information quite recently.

DR. WALLIS: You just got it.

MR. SCOTT: Yes.

DR. WALLIS: Because that was quite an impressive test. I mean, they did the test at the screen, but they also put simulated core.

MR. SCOTT: Since you bring that up, I have a little bit of a concern that I'll bring up. I actually asked to be allowed to be a wall sitter at that meeting and was told I could not, and again, since you brought it up, I really think that for this kind of meeting it would be helpful to, all parties concerned, if we could -- I wouldn't even say anything -- but just sit there and listen to the exchange that went on.

We really did want to go to that meeting, and we were told we couldn't because that was the rules of the quadripartite agreement.

So that's just a point. I would just ask that if you all have occasion to reconsider those rules or whatever they are, you might want to consider that, but we would greatly have appreciated the opportunity just to listen in.

CHAIRMAN BANERJEE: Well, you know, Mike, we were not even aware of all this that happened. It never came to ACRS for an opinion.

MR. DINGLER: What, all of what?

CHAIRMAN BANERJEE: That you were not allowed to come to the meeting.

MR. SCOTT: I raised it with the Executive Director.

CHAIRMAN BANERJEE: Well, it was never raised with us. Maybe the Executive Director knows rules and regulations better than we do.

MEMBER CORRADINI: That would be a high probability.

CHAIRMAN BANERJEE: Yes. But, on the other hand, I sent you all the slides, but I wasn't even aware of that.

MR. SCOTT: Yeah, I asked to go. As a matter of fact, our counterparts, we had asked to meet with I think it was the French, and they said, "Well, we've got a lot going on right now, but why don't you come to the European quadripartite?"

And I said, "That sounds like a good idea." And it just didn't play out. So that was disappointing to me. I'll just leave it at that.

MR. KLEIN: If I could add one other item to the sample that's being passed around, I'd just like to point out that the active strainer bypassed much more material obviously than it passed the strainer, and that, in fact, created downstream issues, and that's why a number of licensees abandoned the active strainer approach.

So as you see, the amount of debris in that vial that's being passed around, that is not representative of a passive strain.

CHAIRMAN BANERJEE: Well, the DFO here just did a rough calculation and told me that the open area in the screen is about 50 square feet -- core inlet. Sorry. Core inlet, which is quite a bit smaller than the open area in the screen.

MR. SCOTT: But as was mentioned, the debris loading on the core will be much, much lower than the loading on the screens, as well.

CHAIRMAN BANERJEE: It depends on what the bypass is.

MR. SCOTT: True, but what we're here to tell you is that the observations have been that the strainers are quite good at capturing the material.

CHAIRMAN BANERJEE: Right. Now, you are measuring those. That's why we asked you in the July meeting or whenever to let us know what those numbers were actually, actually measured bypass.

MR. SCOTT: The results of the analysis and/or testing of bypass we agreed to talk to you about in July, yes.

DR. WALLIS: So the strainer that you're putting in is something like 5,000 square feet.

MR. SCOTT: Anywhere from 1,000 to 5,000 probably, yes.

DR. WALLIS: So we've got a factor of 100 in area.

MR. SCOTT: Yes.

DR. WALLIS: And then you've got this magic one foot cubed per 1,000 square feet. If it were two or three foot cubed per 1,000 square feet, that might make a difference. It's a rather important number to get right, it seems, in view of this huge area difference.

MR. SCOTT: Okay.

DR. WALLIS: I guess we'll see the evidence for that.

CHAIRMAN BANERJEE: Go ahead.

MR. ANDREYCHEK: Thank you.

I think we're done with this slide. Let's go to the next one, please.

DR. WALLIS: That's a very easy slide to understand. Let's go to something difficult.

MR. ANDREYCHEK: Thank you.

Specific areas we addressed in the work presented in the WCAP for blockage of the core inlet, both the inlet top and bottom. Collection debris on fuel grids and rods and collection of production material on fuel clads.

We also looked at protective coatings, debris that might be formed and carried in towards the sump and it might deposit on fuel rods.

And we also considered boric acid precipitation. Now, that's not to presume that we are addressing boric acid precipitation in another context that the NRC is --

DR. WALLIS: Yeah, I was a bit surprised there. You came to the conclusion that everything mixed up just is assumed in the boric acid precipitation analysis, but surely if you've got 99 percent of the core blocked, you're not going to get the same mixing.

MR. ANDREYCHEK: I don't disagree that the mixing volume might be affected at that point. However, I think we're demonstrating that we don't get the 99 percent blockage. That 99 percent blockage calculation that was done using COBRA TRAC --

DR. WALLIS: So I guess this is where, again, I would say let's be more quantitative. Let's see how much deposition do we need or how much resistance do we need before we begin to affect this mixing to the point where we have to worry about it.

I didn't see that to evaluate it.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: Do you take the sort of chemical effects that we see associated with pressure losses across screens into account, where we get all of this gooey stuff, which we look at it in the experiments?

MR. ANDREYCHEK: I'm not sure I understand the context of the question.

CHAIRMAN BANERJEE: Well, the chemical effects which occur increase the pressure losses across the screens enormously, and if you look at the material, it's very gooey on occasion. You know, it's sort of not just deposition or anything.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: It's a different sort of consistency. Would this happen at the core inlet? Could these chemical effects go through to that?

MR. ANDREYCHEK: From the experimental information that I've seen in terms of head loss testing and whatnot, you don't see that that, quote, goo would tend to form at the core inlet. It would be captured prior to getting -- some that would get through would be relatively small amounts because it would be captured at the screen proper.

DR. WALLIS: Only if there's a fiber mat on the screen. The open areas of the screen, I think that the precipitates or the goo or whatever would go right though.

MR. ANDREYCHEK: Well, the precipitates would certainly, but the velocities approaching the screens for the PWRs were sufficiently small, and we are looking on the order of .01 or less feet per second, that if they're gooey enough to catch on the fuel or on the core inlet, they would also catch on the screens.

CHAIRMAN BANERJEE: I'm just asking a question here for information. Is the goo generated in situ or is the goo captured?

MR. KLEIN: Tim, if I could maybe add here.

MR. ANDREYCHEK: Sure, go ahead, Paul.

MR. KLEIN: I think that there's a few things to consider with respect to the chemical products that may form in the sump. For the purposes of their analyses, they assume that all of that material passes through the core. In reality, we think the aluminum hydroxide type precipitates, which may be the largest portion of chemical precipitates, would probably be dissolved at higher temperatures.

However, we're aware of at least one set of licensee tests where they assumed 100 percent of the precipitate had passed through the vessel, and then they did some mock-up tests with the fiber debris bed that was based on bypass tests, and then they added 100 percent of their chemical load assuming that it all passed, and they had an acceptable result on pressure drop through that mixture.

DR. WALLIS: So there's a lot of additional evidence which we haven't seen like this?

MR. KLEIN: I think there is some additional evidence that you haven't seen.

DR. WALLIS: Because what's missing from this report is this kind of experimental evidence.

MR. ANDREYCHEK: And I think Paul pointed out that that was on a plant specific or licensee specific calculation or test.

MR. KLEIN: And it was a licensee specific test that we recently became aware of as their GL supplement package included some details on the test.

CHAIRMAN BANERJEE: I guess what we're asking is you've got a flow area here, which is a factor of ten or maybe even lower than the screen area. Okay? And the hold sizes are even smaller. So are we going to get an acceptable pressure loss across this or not? That's really -- and what is the maximum pressure loss you can tolerate? Because the driving head at most is three psi across this screen, the coarse inlet screen.

So that is the issue which we're trying to -- and we didn't get a clear answer from the WCAP to that because in some sense the inlet geometry was not clear. I didn't even know what the hold sizes were. I didn't know what the open area was compared to the screen. I didn't know what the available pressure loss was.

So in some sense we don't have the change to even do a back-of-the-envelope calculation at the moment, which would be nice if we could do that.

I mean, I'm prepared to buy the thing at these low velocities function so that you distribute it. The question is can you get it in.

MR. ANDREYCHEK: Okay. Well, bear with me, and I think we can show you some data that you didn't see in the WCAP that might help address that question.

DR. KRESS: On this slide you have up there, could you elaborate on what the concern with boric acid precipitation is?

MR. ANDREYCHEK: The issue with boric acid precipitation relative to GSI-191 was a question that was asked of us, that whether or not debris concentration, if it were to increase in the core region while it was boiling, would affect boric acid precipitation.

And part of the answer to that would be that we didn't see that for a variety of reasons, but furthermore, the mixing volumes that were used would not be affected.

DR. KRESS: Oh, you were questioning the ability of the boric acid to prevent re-criticality?

MR. ANDREYCHEK: Well, yes.

DR. KRESS: Oh, you weren't concerned about boric acid being part of the blockage problem.

MR. ANDREYCHEK: That's correct. We demonstrate, I think, that the mixing volume calculations are used and the flow paths for mixing still remain valid.

DR. KRESS: Still, I see.

MR. ANDREYCHEK: So we tried to take that issue off the table by demonstrating the current licensing basis calculations remain valid.

DR. LANDRY: The concern that the staff had, Tom, was that you could put enough debris in to sufficiently reduce the mixing volume that you could cause problems with boric acid dilution calculation, and it wasn't a problem with the boric acid itself or the problem that you could cause mixing volume problems. You could cause other chemicals to come in and you would alter the precipitation properties of boric acid to the point that you would negate all of the analyses.

So one of the things that I'll say this afternoon is that when we consider the boric acid precipitation, this has to be recalculated on a plant specific basis so that they can take reductions in mixing volume and still maintain the proper dilution of boric acid.

DR. KRESS: Well, let me ask another question then. It has been my impression that when you boil away boric acid solution in water at relatively low pressures like we have here that the boric acid goes with the stream and is continuously being reduced in concentration in the liquid.

At some point your boric acid is gone back to containment. Has that been an issue that's been raised at all?

DR. LANDRY: That was one of the questions that was raised in the RAIs that we asked on boric acid, that they are going to be sure that they don't have a problem with the concentration and they don't have a problem with reduction of boric acid.

DR. KRESS: And how was that addressed?

DR. LANDRY: They addressed that that's going to be calculated on a plant specific basis because each plant has --

DR. KRESS: Do we have some information on how that was calculated at the time?

DR. LANDRY: They did not do the calculation in this WCAP. What they presented in the WCAP is the methodology and the assumptions to use in performing the plant specific analysis.

DR. WALLIS: Now, the re-criticality, doesn't that occur before recirculation or have I got it wrong? The re-criticality issue with the boric acid dilution, isn't that early on in the first set?

DR. KRESS: Yeah, I would expect the xenon to build up to prevent it anyway in the long term.

DR. LANDRY: That's an early on problem, but we were concerned that now because you're changing mixing volumes with debris, you could affect the boric acid concentration late on also.

DR. WALLIS: Oh, later on in the process.

DR. LANDRY: So we have gone from the

early on and now to the later on.

DR. WALLIS: But isn't it all mixed by -- later on in the process it's all mixed.

DR. LANDRY: But what we wanted to insure was that you could not get into re-criticality problem later.

DR. WALLIS: Well, your concern is a slug of pure water, is what you're concerned about, and what time in the whole event does that occur?

DR. LANDRY: That has to be calculated plant specific.

DR. WALLIS: But isn't it before you start recirculation?

DR. LANDRY: Yes, but we are concerned that that could happen again.

DR. WALLIS: So how does the debris get in there during that time?

DR. LANDRY: That's what we want to make sure, that it doesn't happen. We're trying to cover all bases here.

MR. SCOTT: Wait a minute now. Let me make sure I understand the context of this discussion. We're talking about what's going on during the injection phase? Is that what your question is about?

DR. WALLIS: Well, this re-criticality is very early in the event, isn't it? You just happen to get a slug of water, or have I got it wrong?

MR. SCOTT: Well, I don't know that you've got it wrong, but if we're talking about something that's occurring during the injection phase, it's not part of what we've evaluated --

DR. WALLIS: That's right.

MR. SCOTT: -- for the GSI-191. There are various other technical issues out there.

DR. WALLIS: Then why are you concerned about mixing?

MR. SCOTT: Related to boric acid dilution and so on, there are other technical issues out there. They're not all resolved in conjunction with 191, and anything related to injection is just not part of this.

DR. KRESS: Well, I was concerned about the long term well after the injection because as you boil off the water, the boric acid disappears, but I presume that you have a build-up of xenon that would prevent re-criticality, but I haven't seen the calculations. I don't know what they did with respect to that.

MR. SCOTT: And for this project I don't think they did anything. Okay? It's simply not a question that was evaluated in conjunction with 191. We made the choice. We, the staff, made the choice to -- you know there are various issues out there regarding boric acid and dilution and so on, and it is not being addressed as part of this topical part. If you found anything in the topic report about that, I'd be very surprised.

DR. KRESS: Well, I didn't. That's why I'm asking the question.

MR. SCOTT: Yeah, and I'm here to tell you it's not being resolved as part of GSI-191.

DR. KRESS: Is it a question you guys have?

MR. SCOTT: I know there have been discussions of this sort. It's not my area to be able to answer a detailed question about. It had not been tackled as part of 191.

CHAIRMAN BANERJEE: Let's move on.

MR. ANDREYCHEK: Okay. Slide 10, please.

Okay. This is another slide that will probably draw some comments. With regards to adequate flow to remove decay heat, endeavoring to reach the core even with debris in reaching the RCS, currently sump screen bypass testing, the replacement sump screens demonstrates that you get approximately a cubic foot of debris for every 1,000 square feet of screen area.

Similarly, the data that we're aware of suggests that the fiber length is on the order of approximately 2,000 microns or less, with the majority of the data or the majority of the lengths being less than 1,000 or 750 microns.

And I think the sample that you see there that was passed around is somewhat indicative even though it came from an active screen, and it's probably longer than what you would expect to see through a passive screen.

DR. WALLIS: And what does a cubic foot of debris mean?

MR. ANDREYCHEK: A cubic foot of debris means a cubic foot of fibrous debris.

DR. WALLIS: Yeah, but fibrous debris when it's squashed or --

MR. ANDREYCHEK: No. Bear with me. I'm going to get there. I will get there.

And that's the as manufactured fiberglass. So you get about a cubic foot of the 2.4 pounds per --

DR. WALLIS: So it's really -- when you squash it, it's a lot less than that.

MR. ANDREYCHEK: That's correct. That is

correct. In order to properly--

CHAIRMAN BANERJEE: What are the densities of this you're talking about?

MR. ANDREYCHEK: The density of the as manufactured fiberglass is approximately 2.4 pounds per cubic foot.

CHAIRMAN BANERJEE: And of glass?

MR. ANDREYCHEK: Of class is approximately I think it's like 90 pounds per cubic foot.

DR. WALLIS: It's two and a half times water. So it's more than that.

MR. ANDREYCHEK: Well, maybe it's 160, thereabouts.

CHAIRMAN BANERJEE: So this is two and a half pounds --

MR. ANDREYCHEK: Pounds per cubic foot, and again, that's spun fiberglass in a mat format, and in order to come up with how much gets through there, Graham, we basically shredded up -- measure it first and then shred it up and then see what we -- weigh the mass of what gets through versus what does not get through.

MEMBER CORRADINI: This is to give you your one over 1,000?

MR. ANDREYCHEK: That's correct, Dr.

Corradini.

MEMBER ABDEL-KHALIK: What was the range of values observed?

MR. ANDREYCHEK: For?

MEMBER ABDEL-KHALIK: Around this one cubic foot per thousand.

MR. ANDREYCHEK: On the order of plus or minus ten percent.

MEMBER ABDEL-KHALIK: -That tight a distribution.

MR. ANDREYCHEK: Of the data that I've been made aware of, approximately plus or minus ten percent, yes.

I beg your pardon?

MEMBER ABDEL-KHALIK: How many experiments?

MR. ANDREYCHEK: I believe there were four or five from the different vendors. Each of the vendors reported about one cubic foot, give or take, about ten percent

CHAIRMAN BANERJEE: That's remarkable. I mean with all of these very different screens.

MR. ANDREYCHEK: Well, again, the screen hole sizes were roughly comparable. If you compare the fiber, they're approximately the same way and the velocities are all approximately the same, you would expect to have similar results.

CHAIRMAN BANERJEE: But you have very different screen areas for each of these plants.

MR. ANDREYCHEK: The tests that were run were based on a representative screen area, and then they ratioed the results that they obtained based on a ratio of debris matched the screen area that they were testing, and this is the results that they came up with.

MEMBER ABDEL-KHALIK: How does this number change with the order arrival of the debris to the screen?

MR. ANDREYCHEK: That I can't answer. I can't answer that one. Again, this is the data that was made available to us that we were able to work with, and I can't answer that question.

MEMBER ABDEL-KHALIK: If this is an important enough number and there is a large uncertainty related to the parameters that would affect it, is there a plan to actually collect data that would give you a better estimate of this number?

MR. DINGLER: Each plant has to evaluate their bypass that they take or take appropriate measures to justify that they bypass that and compare it to what we said in the WCAP.

So in other words, we come up with a value that we're using to use the bounding condition in that, and then they have to evaluate that plant specific stuff to have bounding condition or provide reasons if they go above that bounding condition why it's still conservative.

DR. WALLIS: Well, the reason the small fibers don't get through is that the big fibers make a map and they trap a small fibers. So the worst case would be if the turbulence level on the flow pattern in the containment is such that only the short fibers get to the screen and then they all go through. That's the worst case.

I'm not sure we know how to evaluate that.

CHAIRMAN BANERJEE: Well, we'll get some information from the prototypical test because they're measuring the bypass, right or not? Mike?

DR. WALLIS: Yeah, but just throwing everything in together is very different from letting it out in the containment.

MEMBER ABDEL-KHALIK: that's why I find it totally incredible that the uncertainty at this time and this number is plus or minus ten percent.

CHAIRMAN BANERJEE: Let's let Mike answer the question maybe. Will we be getting at least numbers from the prototypical test, the bypass?

MR. SCOTT: That's my understanding, yes.

CHAIRMAN BANERJEE: And will we also know what sort of fibers are getting through or is that too much detail?

MR. SCOTT: I don't know the answer to that off the cuff. I can get that answer for you.

CHAIRMAN BANERJEE: Okay. Thanks.

I think we probably got whatever we want out of this. Why don't you carry on?

DR. WALLIS: Well, you're getting to the crux of the whole thing really.

CHAIRMAN BANERJEE: Yeah.

DR. WALLIS: How typical are these tests where someone throws in some mixture in some kind of an order? How typical is that of what happens in a real containment with real stuff trickling down staircases and going around various bends and settling here and there? How typical is the test of the reality?

That's a basic question.

CHAIRMAN BANERJEE: Well, we have that question for the prototypical tests as well. That was the issue that came up last May, and I think they've tried to address that, if I understand it, to some extent, right?

MR. SCOTT: What we have tried to do is push the vendors through the licensees to conduct a conservative head loss tests, a conservative or prototypical, and that is what we've been focusing on for the last six, eight months.

DR. WALLIS: But you see, there was conservative head loss --

CHAIRMAN BANERJEE: It's not --

DR. WALLIS: -- conservative for bypass.

MR. SCOTT: I understand, and there is guidance out there for bypass as well.

CHAIRMAN BANERJEE: This was an issue that was raised in the meeting you were not able to attend, the quadripartite.

MR. SCOTT: Oh, okay.

CHAIRMAN BANERJEE: The famous quadripartite where there were arguments that actually the worst situation for downstream effects was when the screens were not completely covered so that you didn't get a fiber bed forming and much of the fiber then passed through. This was really the issue, and, therefore, it wasn't the very large breaks that were the problem. It was the intermediate size breaks where you didn't generate all that much debris.

MR. SCOTT: We're certainly aware that what is conservative for a strainer head loss test is not necessarily conservative for bypass testing, and so I'm not able off the cuff to answer that question as to what the assumptions are, but we can get an answer for you and hopefully we can talk about it this afternoon.

DR. WALLIS: Well, can you sort of explore? Can you say let's do a test which is unfavorable to catching the small fibers and see how far we can push that?

You have gone the other way, I think, in saying how can we make it unfavorable for head loss and so you've done that and made it as bad as you can. Can you contrive a test which makes the bypass worse and then say, "How conservative do you need to be in that direction?"

MR. SCOTT: Why don't you let me take a look-up to bring the correct staff person in here who can answer in some detail what our assumptions are and the way we have gone with regard to bypass testing? I'm just not able to do that and I don't want to commit to something until I have the opportunity to have the staff person come in and talk about it, and

I would propose to try to bring that person in this afternoon.

CHAIRMAN BANERJEE: The other issue, Mike, that came up, and I think it came up during the May meeting, was also that some of these screens have a low normal velocity through them and they have a large area, but the parallel velocity can be pretty high. So you actually keep stuff entrained because of the high level of turbulence going parallel to the screen. So the screen is like this and a flow like that, and some of it is being sucked off.

So it doesn't drop out. It stays suspended, and then you have a low parallel velocity and large screen area, and it gets carried through the screen. So this was an issue which, I mean, it can affect head loss and it also can affect bypass.

With these very large screen areas, you may not even form a fiber match.

MR. SCOTT: That is correct, and again, the right person to address what we do about bypass is not here.

DR. WALLIS: Well, the worst thing would be if you had kind of like a mass spectrograph where the long fibers get caught in one place and then the short fibers and then the particulate. So the long fibers go one place and the short fibers go through because there are no longer any long fibers there.

I don't know if this happens, but maybe Dr. Banerjee can contrive a turbulence model which makes it happen.

CHAIRMAN BANERJEE: Well, one of the things which has been, I think, a continuing concern, and implicitly that's what you're seeing here, is the screens have thousands of square feet potentially of open area. The core has a much smaller region and holes of roughly the same size.

So if the screen is becoming too large, then things may pass through and get stuck in the core basically. That's really --

MR. SCOTT: And we understand the concern, and again, we're not prepared right now to talk about bypass in that detail. I propose to bring someone in this afternoon who can address it. Okay?

CHAIRMAN BANERJEE: Okay. Let's move on.

MR. ANDREYCHEK: Again, the sump screen hole sizes limit the amount of bypass particulates in fiber, the hole sizes being approximately a tenth of an inch or sometimes less.

There is a single assembly testing that indicates that fibrous and particulate debris that bypass the sump screen is not likely to build an impenetrable blockage at the core inlet and, Dr. Wallis, before you ask, the data is on the next page.

DR. WALLIS: How much is the actual blockage?

MR. ANDREYCHEK: Yes.

DR. WALLIS: And then you say this, but then the Areva tests we saw the stuff that bypassed their screen got stuck on the spacers. It didn't get stuck in this screen underneath this core.

CHAIRMAN BANERJEE: Which is sort of strange.

DR. WALLIS: First spacer row.

MR. ANDREYCHEK: Well, all I can tell you is that in this particular test, what was used was a Combustion Engineering debris trapping device that was --

DR. WALLIS: When it comes to spacers, you can't just look at the hole between the spacers, the flow area or the flow size. You've got to look at the fact that the spacers have sharp edges to them, which are wonderful for catching particles, the fibers.

MR. ANDREYCHEK: And I think you'll see from the photographs that Dr. Landry will share with you this afternoon and was passed around earlier --

DR. WALLIS: I looked at those and I couldn't understand them.

MR. ANDREYCHEK: Well, again, bear with us until we make this presentation.

DR. WALLIS: Okay.

MR. ANDREYCHEK: And it does demonstrate that the fibers -- there is some fiber collection on them, but it isn't -- doesn't create a mat.

DR. LANDRY: Also keep in mind when you're looking at the German procedures they inject from the top. They inject the material on top and it settles down into the core. So they're capturing in a different manner than injecting from the bottom and having to be forced to capture as it moves up through the spacer grids.

DR. WALLIS: Aren't there some cases -- maybe not. It's important how the debris approaches the strainer.

DR. LANDRY: But the information that was shared with us by the German regulators was information from tests where they injected on the low flow and dropped the material on top of the core and then looked at where it captured.

DR. WALLIS: That's what they do in Switzerland, too.

DR. LANDRY: It was a very different configuration than is being --

DR. WALLIS: There's no containment where you actually drop the material close to the strainer as far as I know.

DR. LANDRY: Right.

DR. WALLIS: So why are people doing tests like that?

DR. LANDRY: Because it's their configuration.

DR. WALLIS: But it's not the way the debris arrives at any strainer.

DR. LANDRY: They have different regulations on what they will tolerate.

CHAIRMAN BANERJEE: They have no allowance for core --

DR. LANDRY: They will not allow any heat-up at all.

MR. SCOTT: I think there's a miscommunication here. You're talking about ECCS strainer.

DR. WALLIS: Yes.

MR. SCOTT: He's talking about what happens in the core, not at the ECCS strainer.

DR. WALLIS: I thought he was talking

about how they put the debris into the pool before the ECCS strainer.

MR. SCOTT: No. He's talking about how it gets to the core and how it's injected by the ECCS --

DR. WALLIS: Well, it has to flow up. I mean in the German test it went through the strainer and then it came into the core.

MR. SCOTT: But the point that Ralph is making is that our understanding is for the German plants, it's equivalent to the UPI, right?

DR. LANDRY: Yes.

MR. SCOTT: It doesn't come through the bottom through these debris cavities.

DR. WALLIS: On the test that we saw it came in through the bottom. I don't know what it did in the plants, but in the test that we saw, right, Sanjoy, or am I confused?

CHAIRMAN BANERJEE: Yeah, they were going through the --

DR. WALLIS: It went through the ECC strainer. Then we went through a pipe, and then it came up into the core and it collected on the first row of grid spaces. You could see it. It was definitely there. It was quite a big blanket. It wasn't impenetrable, but it was there. It was substantial enough to notice.

CHAIRMAN BANERJEE: And it was surprising because they had some core inlet device which should have apparently capture debris, but didn't.

MR. SCOTT: Well, none of those devices are going to be 100 percent efficient, and the test that I happened to see at CDI, you could see the vast majority of the material was captured at the bottom plate, but some of it did get through, and you could see that some of it, I would say a relatively small amount, collected around the spacers. That's true.

DR. WALLIS: So the question really is how much and what blockage does it create.

MR. SCOTT: Well, and I believe that Westinghouse folks are going to talk to you about what they did and the staff will bring up the same information in the staff presentation as to what we observe and what the assumptions were and, therefore, why the staff and the applicant both considered this situation to be bounded.

CHAIRMAN BANERJEE: Why don't we move on to the next slide?

DR. WALLIS: It looks important.

MR. ANDREYCHEK: This slide provides a table of information about head loss versus debris collection, actually debris that was provided to the bottom of a single fuel assembly channel, and again, Dr. Landry has a couple of photographs that he passed around and will talk about this a little later this afternoon, but this is the information, head loss information. It talks about and gives the --

DR. WALLIS: This is head loss at a certain flow rate?

MR. ANDREYCHEK: That's correct, and the flow rate is 60 ppm on the left-hand side of the column.

DR. WALLIS: And the flow rate is the flow rate necessary to meet boil-off or --

MR. ANDREYCHEK: No, this was just the flow rate for that particular fuel assembly channel. This was at their flow rates for their ECCS system.

CHAIRMAN BANERJEE: The flow rate is determined by the head in the downcomer.

MR. ANDREYCHEK: This was a pump system.

CHAIRMAN BANERJEE: Oh.

MR. ANDREYCHEK: This was a closed loop --

CHAIRMAN BANERJEE: Are you going to show us the experiments that were set up somewhere?

MR. ANDREYCHEK: Again, Dr. Landry has the photograph or drawings that he will show you.

MEMBER CORRADINI: That's what was passed around.

MR. ANDREYCHEK: That's what was passed around earlier. Yes, Dr. Corradini.

MEMBER CORRADINI: So this corresponds roughly to 1,200 gpm through the core.

MR. ANDREYCHEK: That's correct. Actually there are 217 assemblies. So you're in the 1,200 gpm range.

MR. SCOTT: I'll tell you what. Since the question is now, why don't -- it's not in your presentation?

MR. ANDREYCHEK: I did not put it in here, no.

MR. SCOTT: Well, why don't we call it up out of Ralph's presentation so that the Committee can see it?

MR. ANDREYCHEK: sure.

DR. WALLIS: I think we have to understand what this table means.

CHAIRMAN BANERJEE: Or even what the system looks like.

MR. SCOTT: We're working on it.

CHAIRMAN BANERJEE: So while you're working on it, we'll discuss this table a little more?

MR. ANDREYCHEK: Sure. Moving from left to right, the fibrous mass that was used is presented in the next column, and then the volume assuming the 2.4 pounds per cubic foot density of what the fiber volume was installed is in the next column.

Using the 217 fuel assemblies, I calculated the volume of fibrous debris that would appear inlet of the core for that particular assembly.

In a similar looking at the particulate mass at one assembly, there were two tests, two cases considered, one with no particulates and another one with some particulate loading for the same amount of fiber material.

DR. WALLIS: And no chemical effects?

MR. ANDREYCHEK: There were no chemical effects that were used in this case.

CHAIRMAN BANERJEE: When you say the 4.4 feet cubed there, volume, the last item in your table, the volume of one assembly, is that -- how many square feet of screen area or whatever would that typically correspond to?

MR. ANDREYCHEK: The assemblies are approximately eight inches square, in that neighborhood, approximately eight inches on a side, approximately.

MEMBER CORRADINI: Actual height?

MR. ANDREYCHEK: No, no, no. Not fully height. This was not a full height test. This was on the order of about three grid spans, maybe two grid spans that were used. Yes, that's correct.

DR. WALLIS: So you expect the ACRS to reach a decision in three weeks about this when you keep producing new evidence which we haven't seen before and we haven't got any kind of a report that describes it? I find myself in a somewhat difficult position. I mean, I would write a report that says I raised all of these questions and they started to answer them in the presentation, but I don't quite know how to conclude anything.

That's what my report would look like at the moment.

MR. SCOTT: Several of the subject areas that you've asked about are covered in other documents, such as the NEI Guidance Report, 2004, and the staff safety evaluation of it. That's why I'm going to ask staff members to come in this afternoon and talk about what's already out there on the street in other documents.

It is true that the WCAP did not, I guess, reiterate that information. Now, whether that will satisfy your question, I don't know, but there are several items here like bypass assumptions that have been previously addressed. So why don't you wait and see what we answer this afternoon.

CHAIRMAN BANERJEE: Do you need more time this afternoon, Mike?

MR. SCOTT: You never know. We're available.

DR. WALLIS: We have tomorrow, too. No, we don't have tomorrow.

CHAIRMAN BANERJEE: I think we should plan on your presentation taking a little longer then that's on the books right now.

MR. SCOTT: That's fine.

CHAIRMAN BANERJEE: We'll be giving you an hour and 15 minutes.

MR. SCOTT: No, we can have more than that.

CHAIRMAN BANERJEE: Or even -- sorry. It's more than that, yes. You've got more than that.

MR. SCOTT: Well, it's not a lot. Yeah, it looks like about two and a half hours.

CHAIRMAN BANERJEE: Two and a half hours, yes. Sorry.

MR. SCOTT: But if it takes more time than that, then we'll --

CHAIRMAN BANERJEE: Yeah, okay. We'll just go till --

MEMBER ABDEL-KHALIK: Is the entry volume below the assembly in this experiment scaled to represent the lower plenum?

MR. ANDREYCHEK: It was not. It was scaled to provide whatever space is necessary to collect the debris, which the lower plenum would provide you much more space. Typically lower plenums in a PWR on the order of -- or four-loop PWR -- on the order of several 450 to 500 cubic feet lower plenum volume, in that order.

MEMBER ABDEL-KHALIK: Four hundred and fifty cubic feet, the lower plenum, and you're telling us that in one of the experiments the volume of the debris at the entrance to the core is 86 cubic feet?

MR. ANDREYCHEK: That would have been for this particular limiting test, yes.

MEMBER ABDEL-KHALIK: And you think that the way the experiment is designed in terms of the size of this volume upstream of the bundle would have no impact on the results?

MR. ANDREYCHEK: I'm not sure I understand.

MEMBER ABDEL-KHALIK: I mean, isn't this a critical parameter that the designer of this experiment would have to consider?

MR. ANDREYCHEK: Well, again, if I look for the one assembly, we're talking four cubic feet, .4 cubic feet for a given assembly, and I calculated estimating out what it would take in a typical PWR.

MEMBER ABDEL-KHALIK: What is the volume of this space for this experiment?

MR. ANDREYCHEK: I don't have the specific numbers. This was not my test. We were given the data to use in terms of here's what the head loss is, here's the amount of mass that we put in for both fiber and particulate, and here's the flow velocities we used. I do not have specific design information about the test facility that was used to run the test.

CHAIRMAN BANERJEE: I guess you're asking with this 86 cubic feet. That's a significant part of the volume of the lower plenum.

MEMBER ABDEL-KHALIK: Right. I'm trying to figure out, you know, how much stock I should take in the results of this experiment, and the first question that I would ask is, you know, how was the experimental set-up designed.

MR. ANDREYCHEK: Well, can I ask -- let me reflect back --

MEMBER ABDEL-KHALIK: How prototypical is this to what I would expect? And then based on that, we can evaluate the results.

MR. DINGLER: I think we're misconstruing. The volume for the test was .4 cubic feet. They upped that in the second. If we had all of the assemblies, then that would be the entrance at the core.

CHAIRMAN BANERJEE: Sure. That's exactly the question he's asking. How large is the lower plenum volume and what fraction of that is this 86.

MR. ANDREYCHEK: And actually, I would ask you to look at things perhaps a little differently if I may. Okay? And that is if we go back and if we take the number of approximately one cubic foot fiber bypass for a screen, and let's assume I have a 5,000 square foot screen. Then I would be looking at something on the order of about five cubic feet of bypass.

Now, if you want to say, "Well, gee, there's high level of uncertainty associated with that number. I'm not sure I believe your plus or minus ten percent that you've told me earlier," and even if you look at the next number down, which is approximately ten cubic feet of fiber bypass, that's what I would be looking at as what I would really expect to see as bypass through a sump screen.

This was a parametric study done with an active screen design which forced fibers through the screen, and this was as Paul Klein correctly pointed out previously, provides sufficient amount of downstream effects that needed to be evaluated, that licensees that were considering an active strainer step back from it. So --

CHAIRMAN BANERJEE: I guess I'm having problems with your units because when you say one cubic feet, 1,000 square feet, it must depend on time in some way. You've got to flow through this. Unless you're assuming that this is an integral measure over a day, five days, ten days, what is that number?

DR. WALLIS: Sanjoy, it comes through at the beginning. It doesn't come through at all later on. I think that's what they're saying.

MR. ANDREYCHEK: That's correct.

DR. WALLIS: So it's a one shot.

CHAIRMAN BANERJEE: Oh.

MEMBER CORRADINI: It's asymptotes out.

MR. ANDREYCHEK: That's correct.

CHAIRMAN BANERJEE: Is that what the experiments show, that it asymptotes out?

DR. WALLIS: It shuts off.

CHAIRMAN BANERJEE: Does it?

MEMBER CORRADINI: Yes.

CHAIRMAN BANERJEE: If it shuts off, then is there no flow through the screen?

MEMBER MAYNARD: As I recall from the presentations from the industry, from the vendors last May, I think that's what they were showing because they talked about each one of the designs. Each one of them came in independently and talked about the results, and I think they were all coming pretty close to that.

CHAIRMAN BANERJEE: Well, what are the occurrences?

MR. KLEIN: You create a more effective filtering bed width time so that the amount of bypass drops significantly compared to the initial start of recirculation when you have a bare strainer.

CHAIRMAN BANERJEE: Right. Now, imagine that you've got a large screen. How long does it take to cover 5,000 square feet or even 2,000 square feet?

MR. KLEIN: There is some time dependency to that, and I think that Mike Scott has indicated he's going to try to bring the right person here this afternoon to address those type of questions.

CHAIRMAN BANERJEE: So this is an integral measure. They're saying only one cubic feet per 1,000 square feet gets through eventually.

MR. ANDREYCHEK: Yes.

MEMBER CORRADINI: To key off of that, you were on your way to explaining. So let's say we had one. How does that one translate into in this matrix? Where does that one cubic foot for 1,000 square feet of flow and you said let's say it was 5,000. I don't really care.

MR. ANDREYCHEK: Okay.

MEMBER CORRADINI: How does that translate into this matrix so that I can understand where does that number fit in this matrix? Because I've been watching you guys go at each other, and I still don't know where that is.

DR. WALLIS: Is it the third column here?

MR. ANDREYCHEK: It's the third column, volume at the entrance to the core. If I had a 5,000 square foot strainer and I had fibrous debris and I accepted the one cubic foot per 5,000 square feet of screen area, and I had enough fiber that I had to worry about it, I would be looking at approximately five cubic foot of material at a density of 2.4 pounds per cubic feet that would collect on and be available to collect on the core.

DR. WALLIS: Now, Tim, if I were very conservative, I'd say five cubic foot over 50 square foot of core area is over an inch thickness of fiber everywhere, and I think an inch thickness of fiber plus chemicals, plus particles at ANL produced complete blockage of the screen.

So if I wanted to be very conservative, I could say you would block the whole thing, if I just took that one inch thickness of fiber everybody and added the chemicals and particles which were added to some of the so-called confirmatory tests.

Now, I'm not saying this is reality in any way whatsoever.

MEMBER CORRADINI: I don't think your calculation is correct.

DR. WALLIS: Why not? Five cubic foot over 50 foot square is over an inch --

MEMBER CORRADINI: Fifty foot square?

CHAIRMAN BANERJEE: It's the flow area.

MR. ANDREYCHEK: The flow area in the core proper.

DR. WALLIS: Core flow area we were told is 50 square feet.

CHAIRMAN BANERJEE: That's a rough number.

DR. WALLIS: If we spread it everywhere and if this call behaves like the screen at Argonne and if you have chemicals and particles, you would block the core. Now, I'm not saying this in any way is reality, but it's just as easy to do this calculation.

MR. DINGLER: Dr. Wallis, that's why we looked at this what we're doing and we're going to get defense in depth calculations that we've blocked the core 90 --

DR. WALLIS: See, you're saying the head loss is one inch here. I'm saying if you go to a confirmatory test with the same amount of fiber --

MR. DINGLER: And you've got to keep in mind one was vertical.

DR. WALLIS: -- you can find a test which is blocking it completely.

MR. DINGLER: One is vertical down and one is vertical going up.

DR. WALLIS: Yeah, but if it's uniform, does it matter?

MR. ANDREYCHEK: It does matter. I would disagree with you. It does matter.

MR. DINGLER: And I guess all I'm saying is we want to show this, and then we asked ourselves that same question that you just asked and said we did defense in depth calculations. How much could we block the core to answer your question --

DR. WALLIS: All right. Ninety-nine percent.

MR. DINGLER: -- and see what we could get, and that's why we did both of them, and then we integrally put them together saying we did this. This is what we believe is reality and conservative, and the other one was we went ultra conservative and said what if.

DR. WALLIS: But you see, if you had another column here which said measure head loss as in this experiment, which you've got here, and then you had another column which said measure head loss at Argonne National Lab using the same fiber loading and particles and chemicals and you'd find it's 100 times as much, that would be telling us something, it seems ot me.

MR. KLEIN: I don't think it's realistic to assume though under the temperatures that you'll see on the inlet to the core you're going to have a similar response by the precipitate that you have at the entrance to the sump stream.

DR. WALLIS: I think that's probably

right, but I can make up the Argonne experiment and make that column, and anybody else can do it, too.

CHAIRMAN BANERJEE: Well, how much higher are the temperatures? Why is the temperature different in the core? Heat is being transferred against the flow?

MR. KLEIN: I think a lot of the Argonne data, keep in mind, was done at, you know, 80 degrees Fahrenheit ambient temperature. What we've seen in bench top tests is as you warm the water there is a tendency for aluminum hydroxide type precipitates to go back into solution.

So if you assume higher temperatures, the precipitates in a lot of cases may be in solution, not acting as the --

CHAIRMAN BANERJEE: Why is the core entrance is the temperature higher?

MR. KLEIN: Your sump fluids will be at higher temperatures in the early stages of an accident.

CHAIRMAN BANERJEE: So is it because of the state of the accident you're at?

MR. KLEIN: Maybe some representative can --

CHAIRMAN BANERJEE: I mean why should the temperature be different here than from the sump screen?

MR. ANDREYCHEK: If I may, Dr. Banerjee, I think the issue is that the Argonne test was run at near ambient conditions, and what we're looking at in the reactor core or in the plenums is temperatures on the order of approximately 260 degrees Fahrenheit. Ergo, the amount of particulates that would be available for filtering and by the fiber bed in the Argonne tests were much greater than what you would expect to see in another reactor core because of the temperatures --

CHAIRMAN BANERJEE: This is because of sump temperatures. I mean, there should not be any difference.

MR. ANDREYCHEK: I'm not disagreeing, but let's again focus on what's the difference between the Argonne tests and what we're dealing with at the reactor core. What the Argonne test showed was materials at ambient conditions, approximately 80 degrees Fahrenheit, and you will get sodium aluminum hydroxide or aluminum oxyhydroxide precipitates at those temperatures. What you'd expect to see at the prototypic conditions after an accident at 260 or so degrees Fahrenheit, those materials would not be in precipitate form. They'd be in solution.

DR. WALLIS: There were some materials that had reverse solubility.

MR. ANDREYCHEK: Those are calcium based products.

DR. WALLIS: But those are others, cal-cil type.

MR. ANDREYCHEK: That's correct, sir.

CHAIRMAN BANERJEE: I am sort of confused. This is suppose to work for 30 days, right?

MR. ANDREYCHEK: That's correct.

CHAIRMAN BANERJEE: If it goes into solution and comes out some time later because things are cooling off, it's going to do an equal amount of damage, right?

What is the lowest temperature that the sump gets to?

MR. ANDREYCHEK: Long term?

CHAIRMAN BANERJEE: In this period.

MR. ANDREYCHEK: It certainly can be on the order of 120 degrees or so.

CHAIRMAN BANERJEE: So of course you have to look at that condition.

MR. ANDREYCHEK: And long term where it's going to precipitate out at could be in the containment well away from the screen, out of -- and therefore not part of the equation.

CHAIRMAN BANERJEE: Yeah, but we don't know. We don't know where the precipitate -- how it will precipitate, whatever it will do, but it seems that one has to take that as the temperature, right, rather than immediately after? Because if it goes into solution at some point, it will come out of solution.

I don't think that's a very strong argument.

DR. WALLIS: I was going to say with the number of surprises we've had in this field over the past few years, I would think that guessing that a different temperature is going to be better is a little precarious unless you have a test.

MR. KLEIN: I would argue with respect to chemical precipitates, we have dozens of tests that would talk to the temperature dependence of precipitate formation, and I guess the contrast I was trying to react to react to was the earlier comment that if we saw in the Argonne test that it caused blockages, you might see a similar thing here, and I was trying to point out a fundamental difference between the ANL tests and what's going on in this particular situation.

The ANL tests, one of the ways that we drove precipitation would be to add in excess of aluminum to the solution and then drop the temperature from 140 degrees to 80 degrees to cause precipitation.

CHAIRMAN BANERJEE: But when you do the prototypical tests for the plants, are you heating up the water to correspond to sump conditions?

MR. KLEIN: I think it depends on the particular vendor approach. In some cases they do a room temperature test and then they add premixed precipitate, the WCAP surrogate, if you will.

In other cases, people have chosen to put all plant materials into a 30-day integrated test and then follow a realistic temperature pH profile to see what happens, and in those cases, there's much less precipitate that forms and is predicted by the WCAP calculation.

CHAIRMAN BANERJEE: Yeah, we know that the WCAP surrogate is very conservative. That everybody agreed to way back, but in this case do they actually require the test to meet the regulation or to do the pH and the temperature profile test?

MR. KLEIN: I guess in our expectations of licensees addressing chemical effects we expect them to either add the precipitate the based on the WCAP type approach which we believe is conservative or we expect them to run a representative test that accounts for all of their different variables that might affect the type and amount of precipitates that form.

CHAIRMAN BANERJEE: So just thinking aloud, since this screen area to the core is about ten times smaller, why wouldn't we adopt the same protocol?

MR. KLEIN: In evaluating this topical report, we will address that question, I guess, this afternoon.

CHAIRMAN BANERJEE: Okay. And you didn't put any WCAP precipitates or anything, the surrogates that we're talking about?

MR. ANDREYCHEK: The data that was presented in this table, there were no WCAP precipitates added. This is strictly a debris from the containment test that was run. This test was run I want to say probably about two years ago while the WCAP chemical works were still being ongoing.

CHAIRMAN BANERJEE: Okay. You've made a remark about the gravity here. So do you expect these fibers to settle, these tiny little fibers? Is there a significant settling velocity?

I mean my back hand calculations shows it shouldn't be settling. So gravity --

MR. ANDREYCHEK: -- neutral. There's no question about that. However, as you begin to develop particulates and the velocities, again, for a cold leg break, if you're looking at what gets carried into the core it's based on matching boil-off until you get into hot leg recirculation, which depending upon the time of calculating --

CHAIRMAN BANERJEE: So what are these particulate sizes? What size particles are you talking about?

MR. ANDREYCHEK: Whatever has passed through the sump screen, which --

CHAIRMAN BANERJEE: So which is roughly what?

MR. ANDREYCHEK: Anywhere from several microns to approximately a tenth of an inch perhaps, the size of whatever can get carried through the screen.

CHAIRMAN BANERJEE: And what size do you expect them to settle? What's their settling velocity?

MR. ANDREYCHEK: It shows that on Sheet 10, the size we're anticipating for the bypass destiny.

CHAIRMAN BANERJEE: And what's the settling velocity?

MR. ANDREYCHEK: The settling velocity --

CHAIRMAN BANERJEE: Forgetting turbulence.

MR. ANDREYCHEK: The settling velocity depends upon the density or the specific gravity of the particulates that would be ingested.

CHAIRMAN BANERJEE: Give me one.

MR. ANDREYCHEK: I demonstrated in a paper I wrote back in '85 on this issue that the settling velocity, anything greater than 40 mils would tend to settle out in the lower plenum.

CHAIRMAN BANERJEE: Right.

MR. ANDREYCHEK: So that's the particulates.

CHAIRMAN BANERJEE: But there are lots of particulates which are much smaller than that.

MR. ANDREYCHEK: Could be.

CHAIRMAN BANERJEE: Which brings us back to the size distribution issue and what's bypassing. Okay. Do we have anymore questions on this?

Let's move on.

DR. WALLIS: Well, I'm sorry. Did the fibers collect on the grid or did they go through or what happened?

MR. ANDREYCHEK: The fibers tended to collect on the grid, Graham.

DR. WALLIS: They did? They all collected on the first grid?

MR. ANDREYCHEK: They actually collected on the -- at the bottom nozzle in the photographs that Ralph demonstrated or showed this morning to demonstrate that, and as Mike Scott had mentioned earlier, some of them did pass through, but not many and did collect on --

DR. WALLIS: So this pressure drop that you measured was with the fibers deposited on the --

MR. ANDREYCHEK: Bottom grid.

DR. WALLIS: -- on the bottom grid, not on the spacer grids in the fuel.

MR. ANDREYCHEK: That's correct. That's correct.

DR. WALLIS: And that was where all the fibers were? They all got collected somewhere?

All of these questions, the same questions you ask about other tests.

MR. ANDREYCHEK: This was a closed loop facility.

DR. WALLIS: And then you put the

particles in afterwards or with the fibers?

MR. ANDREYCHEK: Particles we mix with the fibers.

DR. WALLIS: So they went round and round?

MR. ANDREYCHEK: Yes.

DR. WALLIS: Okay. Thank you.

Is this report available?

MR. ANDREYCHEK: This particular report is not available.

DR. WALLIS: This is what we're looking at now on the screen?

MR. ANDREYCHEK: That's correct. This is the rig, and if I may, if you look where the delta P collection is at, the fibers tended to collect just below the cross-hatch plate. What he's pointing to now with the arrow is the bottom nozzle. The support plate simulation is below that. Just below that support plate is where the fibers tended to collect.

There is a photograph that shows a -- there's the test rig, and you can see the first grid strap right above the joint, and there's a second grid strap close to the top of the facility.

MEMBER CORRADINI: And that's the end of the facility?

MR. ANDREYCHEK: That is the end of the

facility. That is correct. That's where the materials, the debris was sucked in from, and that was what it looked like. It's the lower plenum below the fuel assembly that was collecting the debris, and that's what it looked like.

DR. WALLIS: It looks as if it's more preferentially on one side than the other.

MR. ANDREYCHEK: I did not witness the test. I can't comment on that.

DR. WALLIS: If you put it in from one side, it's going to be different from uniform.

MR. ANDREYCHEK: Well, this actually came in from the bottom, and if we looked at the sketch, there was a mixing cone. See the flow diverter deposited the mix.

DR. WALLIS: Ah, a diverter. Okay.

MR. ANDREYCHEK: Yes, sir. So the intent was to try to get a relatively uniform approach to --

DR. WALLIS: You say the upstream turbulence makes a difference to how it deposits and where it goes.

Well, we could go on about this forever.

MR. ANDREYCHEK: And six ppm was not a particularly high velocity.

Let's go back one.

CHAIRMAN BANERJEE: That was an interesting slide after this one.

MR. ANDREYCHEK: This one right here?

CHAIRMAN BANERJEE: No, the graph.

MR. ANDREYCHEK: Can I talk about this one first for just a moment?

CHAIRMAN BANERJEE: Yeah.

MR. ANDREYCHEK: This is what the fiber collection tended to look like. There was a space provided between the assembly and the wall, and again, what you're looking at here is what might have collected on the spacer grid. You saw what was collecting in the lower plena and now this is what's collecting on the spacer grid.

DR. WALLIS: What are we seeing? ICET is some kind of shadow. What's that?

MR. ANDREYCHEK: That's the fibrous debris that's coming through.

DR. WALLIS: It's actually going through sort of a plume in the middle? That stuff is the fibrous debris? The plume?

MR. ANDREYCHEK: Well, it's the total debris.

DR. WALLIS: But it doesn't look very well mixed. It looks as if it's in a single, little plume then.

MR. ANDREYCHEK: Again, I'm looking at one side. I can't tell you what's going on on the other side. This is the available photographs we have, Dr. Wallis. I can't --

DR. WALLIS: But you see, that's the problem with all of these tests. What did they really mean?

CHAIRMAN BANERJEE: Well, let's go on to the next --

DR. WALLIS: I just wonder if Argonne did the same test what they would find. Is there any confirmatory work on this rather important problem?

MR. SCOTT: The staff does not currently plan confirmatory testing associated with GSI 191. These issues are also being evaluated in regard to the new reactor reviews that are going on, and I can't speak to what that -- the reactor organization is doing.

MEMBER CORRADINI: One more point of clarification. You said it, but I want to make sure I understand it. So there's this plexiglass surface around it, and it's designed so that there is no flow bypass. It all must go through the grid, the simulated lower plate, and the grid and the associated grids in the fuel cell, right?

MR. ANDREYCHEK: Right.

MEMBER CORRADINI: So there is no bypass.

MR. ANDREYCHEK: There's nothing to take it outside of the facility. That's right.

MEMBER CORRADINI: What I mean by "bypass" is I'm even worried about the effect of having the fuel assembly -- I want to make sure it's flat up against the plexiglass so that there's no flow around it.

MR. ANDREYCHEK: The bottom nozzle, my understanding was the bottom nozzle is right up against the plexiglass.

MEMBER CORRADINI: And since we're fudging with these things, can you go down one more, one more picture?

CHAIRMAN BANERJEE: Mike, closer to the mic.

MEMBER CORRADINI: Yeah, okay. I'm going to start making love to it in a minute.

(Laughter.)

MEMBER CORRADINI: So I was going to say so go forward a couple of slides, please. So Graham was asking about this. This is just an example of the stuff stirred up just before it gets injected.

MR. ANDREYCHEK: That's in the lower plenum below the fuel assembly.

MEMBER CORRADINI: Thank you.

CHAIRMAN BANERJEE: Now can we have a look at the graph that was right after?

DR. WALLIS: So what do you think about that when you see a picture like this? Do you say the fibers are more on the right or the left or this is a transient or what do you say? Or is it just an illusion of some sort because of the way it's lit?

MR. SCOTT: My recollection of having observed the test --

DR. WALLIS: Oh, you actually saw a test?

MR. SCOTT: This one, yes.

DR. WALLIS: Well, good.

MR. SCOTT: I told you.

DR. WALLIS: We were asking.

MR. SCOTT: I went to one of them at least.

PARTICIPANT: Just not Switzerland.

MR. SCOTT: That's right.

My recollection from observing this test at this lower plenum simulated area was fairly cloudy and full of this stuff. I don't recollect a significant perception of a delta from one side to the other or anything like that. It was quite full of it, and then the area up closer to the bottom nozzle and all --

DR. WALLIS: And when it deposited, did it deposit uniformly?

MR. SCOTT: Well, it didn't much deposit. It kind of hung there, the best --

DR. WALLIS: But when it did deposit, it deposited on the lower plate?

MR. SCOTT: I wouldn't even say it deposited there.

Do we have a picture of -- we don't.

DR. WALLIS: How did you get a head loss if it didn't deposit?

MR. SCOTT: Well, I guess maybe another way of saying it is that it appeared to be a fairly -- pardon my word -- fluffy bed because of the very low flow rate.

DR. WALLIS: In many of these tests, in the confirmatory test is that if you didn't get a uniform bed, you got blow-through or whatever they called it. They got certain places where there was no bed, and that made an enormous difference to the pressure drop.

If you get a uniform blanket everywhere, if you design a test that does that, then you can get thin-bed effects in all kinds of stuff, but all you need is a little bit of maldistribution and a few holes that don't get covered, and the pressure drop is much, much less.

MR. SCOTT: Certainly.

DR. WALLIS: So I'm just wondering what you saw when you looked at the coverage of the grid.

MR. SCOTT: As best I could tell looking at it visually from the side of this assembly, there was a thick I guess you could call it a blanket, but it was a fluffy blanket of stuff in that lower area.

DR. WALLIS: It was uniform over everything?

MR. SCOTT: It was well distributed. I don't recall whether "uniform" would be the right word.

MEMBER BLEY: In the pictures you passed around there was a picture of that lower area, and it looked like it was laying down there in the bottom and only a little fraction was going up. I'm not sure you had that on the viewgraph.

MR. SCOTT: A lot of it stayed, as the picture that we're showing now; a lot of it was in that area. Some of it was up there just below the bottom part of the fuel assembly in a very fluffy blanket, and again, it's partly because the flow rates are so low that it doesn't encourage, I believe, a tightly compressed.

MEMBER BLEY: And that's what -- the trip report you passed around said that.

MR. SCOTT: Is that the one we're talking about?

MEMBER BLEY: Yes, and it implied that most of the stuff lay at the bottom and only a little bit carried up, and they have one picture that really looked like that.

MR. ANDREYCHEK: May I see that Westinghouse trip report, please?

MR. SCOTT: Yeah, I want to be clear here. There's more than one trip report. Obviously, I didn't sign off on a Westinghouse trip report. There is an NRC staff trip report, too, that's in the record.

DR. WALLIS: Well, the reason I'm asking these questions is if this were a student project, I'd be asking exactly the same questions, but what's at stake in a student project might be passing a course. This is something to do with nuclear safety so we ought to be sure we understand what's going on.

MR. SCOTT: Well, the argument that is being made here, well, we haven't had a chance to make the argument yet, but the argument that's being made that Ralph Landry is going to make this afternoon is that there are enough margins here that we feel that the issue has been adequately addressed.

DR. WALLIS: Even if it's much worse than are shown in the tests.

MR. SCOTT: Significantly worse, yes. You know, you can listen to that argument and obviously you may or may not agree to it.

DR. WALLIS: Yeah, I like the argument that no matter where the water comes from as long as it gets in somewhere, it will cool the core as long as there's enough of it. It mixes enough between the channels.

DR. LANDRY: That argument --

DR. WALLIS: There's enough circulation in the core itself, and if it boils in one place it stirs everything up so that it cools the rest of the core.

DR. LANDRY: And that argument we're going to make this afternoon, Graham, when you get through talking about --

DR. WALLIS: And this is all done by the computer, computer models?

DR. LANDRY: Computer models and with the CFD analyses which we did.

DR. WALLIS: Well, that's really what convinced you that it's okay?

DR. LANDRY: Yes.

CHAIRMAN BANERJEE: Well, I think we are at a point where we're almost done with your experiment on debris collection on fuel grids, right?

MR. ANDREYCHEK: Yes.

CHAIRMAN BANERJEE: You haven't still shown us that graph, but I guess that will be done after lunch or whatever.

MR. ANDREYCHEK: Well, that graph actually was --

CHAIRMAN BANERJEE: Was Ralph's.

MR. ANDREYCHEK: -- was Ralph's, and that will be his presentation, yes.

CHAIRMAN BANERJEE: Right. So why don't we do this? If it's agreeable to you, we take a break now. We come back -- I think it's 12:15, isn't it? -- and we come back and pick up where we leave off, which is continue on this collection of material, and then move on to the thermal conductor.

You know, at the rate we're going, this is pretty important stuff that you're telling us, and the experiments are particularly important. So have we done with all of the experiments now?

MR. ANDREYCHEK: Yes.

CHAIRMAN BANERJEE: Or do we have anymore experiments? It's all calculations after this?

MR. ANDREYCHEK: That's correct.

CHAIRMAN BANERJEE: This is the only experiment we're going to see.

MR. ANDREYCHEK: That's correct, from us.

CHAIRMAN BANERJEE: Are we going to see anything from the staff, some experiments as well?

PARTICIPANT: You've got to answer through the microphone.

DR. LANDRY: I thought shaking my head was sufficient.

No.

CHAIRMAN BANERJEE: Fine. So let's take a break for an hour and come back at 1:15.

Thank you.

(Whereupon, at 12:22 p.m., the meeting was recessed for lunch, to reconvene at 1:15 p.m., the same day.)

CHAIRMAN BANERJEE: So, we are going back into session. Sorry for the delay but we had some problems with the recorder. So, we'll just pick up where we left off and keep going. Thanks, Tim, I guess, right?

PWR Owners Group Presentation WCAP-16793-NP

MR. ANDREYCHEK: Yes, thank you. Next slide, Slide 12, is the -- deals with the collection of debris on fuel grids. I'd like to point out that the bottom structure is the bottom nozzle in the photograph or schematic. The next is the first grid.

These grids, and I may have given an inappropriate impression, the flow area between -- the largest dimension, flow dimension in the grids, egg crate design of the grids between the outside diameter of the clad and the corner of the grid is approximately a 115 mils.

The more -- and I may have misled some people this morning when I gave a slightly different dimension with the dimples, but they're fairly wide open compared to the 100 mils of a sump screen or smaller in some cases, like what Mo identified in his plant.

(Whereupon, audio system difficulties resulted in the loss of approximately one minute.)

CHAIRMAN BANERJEE: Okay. So, I'll speak now. Of course, it'll be good for everybody else.

If we could have a diagram with the dimensions of the grid and the inlet as well just to see what sort of holes there are, what sizes they are, and the distribution of holes.

MR. ANDREYCHEK: I believe that we might be able to get something out of FSAR, Final Safety Analysis Report.

CHAIRMAN BANERJEE: That would be good, yes. Thanks.

MR. ANDREYCHEK: Okay. The first subbullet demonstrates any screen -- any debris that bypasses the screen is small dimensionally and volumetrically. This is based on bypass testing that's been done to date.

Again using a variety of different techniques, we found that maximum length tends to be on the order of about 2,000 microns or less and the blockage that might form is limited in length -- height, I should say, and it's not impenetrable to flow. We do get flow through the blockages that we've --

DR. WALLIS: Again, I have read this assertion in the report and then I remember what I saw in Germany. So, I just wonder. When you say not likely, is there really confirmatory data that's convincing that this stuff cannot collect at grid locations?

MR. DINGLER: Dr. Wallis, look, there is some concern. What we want to show is we looked at this and now we want to integrate, put it together and say we used the 96 percent, the 94, to show on there. So, you've got to put it all together and we see that or we show -- we want to show that there's conservativism on --

DR. WALLIS: That's okay, but then these statements, it's not likely, really isn't a very reassuring statement. If you're going to make a statement, it has to be backed up with some facts.

MR. DINGLER: We understand, but based on what we saw, we -- it is not -- we don't -- we didn't see a lot of that being formed on that there. So, I apologize for the bad -- for the worst use of the words.

DR. WALLIS: It's much better now that you do have some experiments which were not in there. That does help a lot.

MR. KRESS: Remind me again. This is a loop recirculated over a long period of time?

MR. ANDREYCHEK: That's correct.

MR. KRESS: How long did you run this thing?

MR. ANDREYCHEK: The criteria is dependent upon equilibrating head loss. So, there might be 20 or 30 volumetric turnovers.

CHAIRMAN BANERJEE: We are still speaking of the CDI experiment, right?

MR. ANDREYCHEK: I am talking about current head loss testing. They run the loop until the head loss equilibrates, less than a certain amount of change over a certain period of time in the head loss and --

CHAIRMAN BANERJEE: Is that a different set of experiments than the one we saw the diagram of that you're talking about?

MR. ANDREYCHEK: Yes, I'm talking about the head loss experiments and what bypasses the sump screen for the head loss.

CHAIRMAN BANERJEE: Okay. So, these are the prototype experiments that have been down right now?

MR. ANDREYCHEK: Yes, yes.

CHAIRMAN BANERJEE: But those are useful for getting the bypass, but there is no fuel assembly downstream of those, is there?

MR. ANDREYCHEK: No.

MR. DINGLER: But again, Dr. Banerjee, keep in mind, you know, we used the word -- we used this when there was no defense in depth. They saw pretty much the same thing.

What we wanted to say -- show is if we used the words "not likely," let's say it did form, we've completely blocked the core 96 percent, that's the defense in depth that shows that there is conservativism --

(Whereupon, audio system difficulties resulted in the loss of approximately four minutes.)

CHAIRMAN BANERJEE: All right. I am going to give in to the suggestion partially. So what I suggest is people keep their questions, except if they're questions for clarification, to the end and then we ask you those questions. So, go fairly quickly.

MEMBER ABDEL-KHALIK: So I have a clarification question. The test data that you referred to in this slide are the same experiments that were used to establish this one cubic foot debris per thousand square foot area of screen?

MR. ANDREYCHEK: The data that I am

referring to is individual plant data that deals with the plant-specific debris loading on their specific screen design and there's -- some of it probably did come from the test that established the one cubic foot per thousand square foot of screen design.

MEMBER ABDEL-KHALIK: So the data that you refer to is actually a larger dataset than the dataset that was used to establish the one cubic foot debris per thousand square foot of screen area?

MR. ANDREYCHEK: Yes, for the purposes of looking at what the size and the amount of bypass is, yes.

MEMBER ABDEL-KHALIK: Okay. Thank you.

MR. ANDREYCHEK: Yes.

CHAIRMAN BANERJEE: Carry on.

MR. ANDREYCHEK: Okay. If we could go to the next slide, please.

Okay. For defense in depth, the first numerical principles analyses demonstrate the core and decay heat removal will continue. I apologize for misspelling principle there, Dr. Wallis. One-dimensional radio heat transfer calculation was used to do that.

Next slide, please. We'll get into that in a little more detail.

With regards to collection of material on fuel cladding, fibrous debris, should it enter into the core region, will not tightly adhere to the surface of fuel cladding. The basis for that statement is a NUKON report, OFC-1. That report received an NRC safety evaluation in 1979 that was mentioned by Dr. Landry earlier.

Three specific items that come out of there are submersion of a rod heated to 2200 degrees Fahrenheit in the fibrous slurry.

CHAIRMAN BANERJEE: 2200 degrees?

MR. ANDREYCHEK: 2200 degrees, yes.

CHAIRMAN BANERJEE: How does the slurry remain a slurry?

MR. ANDREYCHEK: Didn't say the slurry. The rod was heated to 2200 degrees and then submerged in the slurry.

MEMBER CORRADINI: So it's a quench test?

MR. ANDREYCHEK: It's a quench test, yes. Yes, sir.

DR. WALLIS: So you're assuming that the chemicals and things in the sump will not make any difference to this adhering?

MR. ANDREYCHEK: Yes. There was nucleate boiling of the heated rod in the slurry test and then finally film boiling of a heated rod in a slurry and in all three cases, fiber did not adhere to the surface.

MEMBER ABDEL-KHALIK: What do you mean by not tightly adhere? Loosely adhere?

MR. ANDREYCHEK: If you took -- once the test was terminated, if you took a light cloth and wiped it over, the fiber material came off.

MEMBER ABDEL-KHALIK: But nobody's going to do that in real life. Nobody's going to take a cloth and go over the fuel rods.

MR. ANDREYCHEK: Okay.

DR. WALLIS: So someone wiped it off?

MR. ANDREYCHEK: Basically to determine whether or not it had melted on the surface. It did not melt on the surface.

DR. LANDRY: The purpose of this test was to determine if material would tightly adhere to a fuel surface and when the test was run in the 1970s, as Tim just said, a rod was heated to 2200 degrees and then dumped into the slurry. One was placed in the mixture, heated to nucleate boiling and held at nucleate boiling for two hours. That was repeated by heating it to film boiling and holding it in film boiling for two hours.

In all cases, when this specimen was removed from the slurry mixture, there were only light fibers adhering to the surface and they quickly brushed off with no effort, no extra cleaning or no forced removal of the fibers from the surface.

The point of the test was that the fibers did not adhere tightly and did not completely coat or form a blanket on the surface, even under these extraordinary heating conditions.

DR. WALLIS: But tightly is an irrelevant word. The question is did they affect the heat transfer.

DR. LANDRY: Well, they were only individual fibers and it was not in the blanket form.

DR. WALLIS: They were not to affect the heat transfer.

MR. ANDREYCHEK: It could not have affected the heat transfer because the boiling process continued.

DR. LANDRY: This was a static mixture that they were dunked in. It was not a flowing mixture, as you would have in a core. If you have the specimen in a flowing mixture, it might just wash the material off, but this was simply dunked and this is old material, it was not done for this purpose, but we found this report when we were going through how much does debris adhere to the surface and we looked at this report and said not a great deal.

MR. DINGLER: And to answer your question, Dr. Wallis, we provided a bump-up on the heat transfer to account for any uncertainties and to provide conservativisms, whether it bypassed and got into the grid from the bottom or adhered to it, we provided a bump-up factor to our heat transfer to account for anything like that. It gives a conservativism effect.

DR. WALLIS: But there is a problem with these vague terms, like not tightly adhered. It's not really a defined statement, is it?

MR. DINGLER: The only thing I can say is in '79 that's what the test report showed, and I can't say anything different than the '79 test report.

CHAIRMAN BANERJEE: Well, I think we should move on.

MR. ANDREYCHEK: 15. A method to predict chemical deposition on fuel cladding was developed and it's called the LOCADM spreadsheet. It uses an extension of the chemical effects method developed for chemical sump effects, WCAP-16530.

New terminology here, Dr. Wallis. NP-A. A means it's approved. It has a safety evaluation associated with it. It assumes that the deposition is driven by boiling, i.e., whatever boils, whatever volume of mass boils is what -- any material in it is deposited.

All coolant impurities, regardless of chemical form, that are transported to the fuel surface for the boiling purposes would be deposited by the boiling.

DR. WALLIS: I don't understand why it deposits underneath what's already there. There was a figure that showed it being deposited underneath the existing deposit. Did I misunderstand that?

MR. ANDREYCHEK: I think you misunderstood that.

DR. WALLIS: Are you sure?

MR. ANDREYCHEK: Should not have been. I'm not sure which figure.

CHAIRMAN BANERJEE: The figure I saw had little arrows pointing at these different layers and it wasn't entirely clear. Maybe you can show the figure again.

DR. WALLIS: I think it was in the text that it deposited underneath the existing deposit.

CHAIRMAN BANERJEE: It's confusing. Do you have that figure?

MR. ANDREYCHEK: It's, I believe, in the next --

DR. WALLIS: Maybe you can come back to it.

MR. ANDREYCHEK: I believe it's coming in the next slide.

CHAIRMAN BANERJEE: Let's go on till we come to that page.

MR. ANDREYCHEK: Yes. Once plated out, the deposition remains on the rod. There's no redissolution of the material and this particular calculational method is used to demonstrate that we get less than 50 mils of build-up on the clad.

Next slide, please.

MR. DINGLER: The slide you're talking about is 48 and we'll get to that.

MR. ANDREYCHEK: With regards to thermal conductivity values used in the deposition calculations, we looked at three specific types of material layers, other than the clad proper.

One is clad oxide and it's a corrosion product formed by oxidation of the cladding during normal operating conditions; crud, which is deposits on the fuel prior to the LOCA; and then what we call LOCA scale or the chemical deposition, deposits formed on cladding by deposition of corrosion products and scale after the loss of coolant accident.

With regards to cladding oxide chemical conductivity, a value of 2.2 watts per meter degree Kelvin were used for parametric heat-up calculation which I'll describe a little later and that was what I consider to be a more bounding case to look at worst case conditions.

For LOCADM calculations, we used 1.27 watts per meter degree Kelvin and that particular value comes from WCAP-15063-P-A, was approved by the NRC in 2000, and it's based on information that was provided to NRC on operating conditions for fuel and the oxide layer that would build up under operating conditions.

DR. WALLIS: I didn't understand is transported to the fuel surface. It's certainly not by turbulence, is it?

MR. ANDREYCHEK: I am not sure which --

DR. WALLIS: You said all coolant impurity is transported to the surface. What is the mechanism of transport? It's not turbulence, is it?

MR. ANDREYCHEK: No, it's not. Whatever mass of fuel is assumed to be --

DR. WALLIS: It's dragged there by the

boiling?

MR. ANDREYCHEK: That's correct. Whatever mass is assumed to boil, whatever materials, whatever concentration was in the material is deposited.

DR. WALLIS: It's in the material?

MR. ANDREYCHEK: Yes, directly on the cladding at that point, which I think is an extremely conservative approach. It maximizes the deposition.

Next slide. Okay. With regards to crud, it's typically nickel ferrite, nickel metals, nickel oxide, nickel iron, chromium spindles. A variety of different parameters affect the thermal conductivity, such as porosity, thickness and whatever heat flux happens to be running through it, i.e., the temperature of the crud proper. We used a value of .5 watts per meter degree Kelvin in the calculations or .03 BTU/hour degree Fahrenheit.

Next slide, please. For the LOCA scale or chemical deposition, this material is likely to be reaching calcium for many plants, particularly those that have calcium silicate installation materials. We did a literature search and we found a limiting value of approximately .2 watts per meter degree Kelvin or .11 BTU/hour degree Fahrenheit and that is the value that's implemented into LOCADM.

For the purposes of the parametric study, again which I'll describe a little bit later, we used a variety of values to look at what the effect of the thermal conductivity of this material would be on the predicted clad temperature and the range of values we ran was from .1 to .9. We were looking to see if we're getting close to a ledge or cliff with some of the calculations. So that's the reason we used the range of conditions.

And this next slide just provides a summary of the literature search that was done and what information we were looking at to pick a limiting --

MEMBER ABDEL-KHALIK: Now the 800 degree temperature limit applies where?

MR. ANDREYCHEK: I'm sorry. Say that again.

MEMBER ABDEL-KHALIK: The 800 degrees F temperature limit applies where?

MR. ANDREYCHEK: It applies at the surface of the clad.

MEMBER ABDEL-KHALIK: So it's underneath this layer?

MR. ANDREYCHEK: That's correct.

MEMBER ABDEL-KHALIK: Okay. Thank you.

MR. ANDREYCHEK: Okay. Any other questions?

(No response.)

MR. ANDREYCHEK: Okay. The next thing we looked at were different types of coating materials, paints, protective coatings. Three categories of materials were used inside the containment generally: zinc-rich primers, epoxy coatings, and other miscellaneous coatings that might be used on OEM-supplied equipment.

These protective coatings will not adhere to the clad surface due to the low temperatures. Now the clad surface, and I want to perhaps offer a clarification here, when I'm talking about the surface, I'm talking about the surface of the deposition material which stays five-10 degrees above the saturation temperature.

The clad -- the proper -- the clad might rise up a little bit in temperature because of the deposition material, but the surface that would tend to collect coating materials stays at roughly saturated conditions, a couple degrees above saturated, and we're looking at about 260 or so degrees Fahrenheit. These coatings will not adhere. Epoxies are very stable at those conditions.

Boric acid dilution, as noted previously, blockage of the core. When I talk about blockage, I'm talking about no flow, will not occur. The mixing volume assumed for the current licensing basis forecasted dilution evaluations are not affected by this debris collection. Therefore, the currently accepted licensing calculations that demonstrate appropriate boric acid dilution remain valid.

DR. WALLIS: Again, you ought to really say how much blockage does it take to influence the mixing, not simply say that it doesn't occur, so there's no influence. Something occurs and needs to be quantified. Isn't that the right way to do it?

I mean, if there were a thin layer, it would still affect the mixing, wouldn't it? It wouldn't affect the pressure drop necessarily for circulation but it might well inhibit some mixing between two regions.

MR. ANDREYCHEK: Based on the material -- the information that we had and what we saw, we did not --

DR. WALLIS: This is mixing between the lower plenum and what's in the core? Is that what you're talking about?

MR. ANDREYCHEK: That's correct.

DR. WALLIS: Oh, I would think a little bit of deposition would have an effect on that. This assertion just comes out of the blue for me.

MR. DINGLER: Dr. Wallis, it depends on -- again, we said current license basis.

DR. WALLIS: Yes.

MR. DINGLER: In other words, as Dr. Landry said, we have to validate that our current license base is a value. Some plants do not take credit for any mixing in the lower plenum at all for the boron dilution efforts. So, we've got to keep that in mind, is what our current license bases are and how that relates to --

DR. WALLIS: No, I'm not worried about that. I'm just worried about sort of reaching a conclusion based on very fuzzy argument. That's all I'm worried about. I think there's too much of that and really you could do a better job.

CHAIRMAN BANERJEE: I think we should move on because it's clear that 99 percent of the blockage and 99 percent of these arguments are very --

DR. WALLIS: What does that do to boron dilution?

CHAIRMAN BANERJEE: I don't know.

MEMBER ABDEL-KHALIK: Let me just ask you an order of magnitude kind of question. These calculations were done for long-term cooling and by that time, decay heat is what, 1 percent?

MR. ANDREYCHEK: Yes, or lower.

MEMBER ABDEL-KHALIK: So the peak heat flux anywhere in the core is in the order of what? Five times 10 to the 3rd BTUs per hour per square foot?

MR. ANDREYCHEK: Thereabouts, yes.

MEMBER ABDEL-KHALIK: Right. So even if you have 50 mil deposit on the surface of the fuel, the Delta T across that 50 mil layer is what even at the hottest spot where you have the highest heat flux? Five degrees?

MR. ANDREYCHEK: Yes.

MEMBER ABDEL-KHALIK: So why go through all this rather than focus on the important issues?

MR. ANDREYCHEK: When we went through this, we thought this was one of the important issues. I'm not sure what else to tell you. We believed that these were important items. We were being asked questions about deposition. We were being asked questions about whether or not we could cool the core. This was one of the things that we looked at. We believed it to be important.

MEMBER ABDEL-KHALIK: Okay. Thank you.

CHAIRMAN BANERJEE: Let's move on.

MR. ANDREYCHEK: Okay. Next slide. Let's talk about two-loop upper plenum injection plants. Wanted to go through a brief discussion here for a cold leg break, what does an upper plenum injection plant look like. The upper plenum flow must go through the core and out the break. Only a complete blockage would prevent sufficient flow to get into the core cooling.

This flow also maintains core dilution, keeps the boric acid and chemicals dissolved.

DR. WALLIS: Now again, these are unacceptable arguments. You say some flow will enter the core. Okay. That carries fibers with it. How much flow enters? How much is deposited in the core? That's the question you should answer. The statement like minimal doesn't mean anything.

I'm the chairman will want to move on.

CHAIRMAN BANERJEE: Yes. Go ahead.

MR. ANDREYCHEK: Next slide, please. For hot leg breaks, the upper plenum will be well mixed with approximately a thousand gpm flow circulating in the upper plenum and going out the break. Again sorry to use the word again, Dr. Wallis, but some flow will go into the core region, but a majority of the flow will go out the break.

Debris accumulation in the upper plenum will be minimal since the debris will be carried out the break with the excess ECCS flow.

CHAIRMAN BANERJEE: I think what you're seeing is a sort of sensitivity to qualitative unsupported statements. So generally, let's avoid them because there are a lot of them here.

MR. ANDREYCHEK: Yes, there are.

MR. SCOTT: If I may, if I can interject something, I would ask that ultimately you all consider when Ralph Landry talks about it, the staff's rationale for why we found all this in totality to be acceptable and then we'll, of course, ask for your input as to whether you agree or accept our rationale.

What he's going to talk to you about is that yes, there are gaps and weaknesses that you might see in some of this information, but that the margins are quite large and overwhelm that and you may agree or disagree after you hear what we have to say.

I'd just ask that you consider that when we go through the rest of Westinghouse's presentation or the WOG's presentation.

CHAIRMAN BANERJEE: So what I suggest is

that we simply mark the number of qualitative unsupported statements and count them at the end and we just let it go right now.

MR. SCOTT: That would then make it quantitative?

CHAIRMAN BANERJEE: At least make it quantitative with regard to that aspect. Go ahead.

MR. ANDREYCHEK: Okay. Thank you. At the time of switch-over for either the hot leg or cold leg break, the core's completely quenched and the clad temperatures are at or near saturated conditions per the licensing basis calculations for the LOCA.

There's a limited amount of subcooled boiling in the core expected as the coolant is recirculated from the reactor containment sump building and again that's coming in through the upper plenum injection ports and this limits the deposition by boiling.

In summary, we believe that adequate flow is maintained to remove decay heat, even with debris in the coolant. The decay heats will continue to be removed even with debris collection at fuel assembly spacer grids and fibrous debris that should enter the core will not tightly adhere to the surface of the fuel cladding and therefore will not affect significantly the heat transfer based on the experimental data from the testing that was done in 1978-79 time frame.

Using the extension of chemical effects methods developed and presented, WCAP-16530-NP-A. a spreadsheet calculation was developed to predict thermal deposition and plants are asked to look and perform plant-specific calculations with that.

As blockage to the core doesn't occur, mixing volume to assume for the current licensing basis forecasted dilution volumes remain valid.

DR. WALLIS: I guess I have to write a report on this and I thought the most significant summary statement was this numerical analysis that demonstrated the caudate decay heat removal would be achieved in extreme case because that is actually an analysis to back up the statement. We haven't got to that yet. That was the statement which had an analysis behind it --

MR. ANDREYCHEK: Yes.

DR. WALLIS: -- which really went to the heart of the matter.

MR. ANDREYCHEK: Yes.

DR. WALLIS: Some of the other ones, the argument doesn't quite support the conclusion so evidently.

CHAIRMAN BANERJEE: But I suppose they need these arguments to be able to make the other argument, you know. So, if you had fibrous debris tightly adhering to the cladding, then it may lead to a different conclusion obviously.

MR. ANDREYCHEK: Or a different analysis approach.

CHAIRMAN BANERJEE: Yes. So, in some way, this is needed to do the next analysis. So what I suggest is instead of taking questions right now, let's move on to the next analysis.

MR. ANDREYCHEK: Okay. The next section is defense in depth calculations for long-term core cooling and, Dr. Wallis, this is the COBRA TRAC calculations.

Okay. Next slide. These calculations were performed to demonstrate the defense in depth. They are extreme cases and I want to stress that. We believe they're very extreme cases in that they assume total blockage, no flow through certain portions of the core.

CHAIRMAN BANERJEE: I really need a clarification there. When you say it's an extreme case, what you're saying is that some parts of the core are completely blocked and others are open.

What happens if all of it is 99 percent blocked? So, if you had a uniform mat which extended over the whole core in that region and there was a high-pressure loss through that, as we see through screens, for example, wouldn't that be more of an extreme case?

MR. DINGLER: It may not be, Dr. Banerjee. What we showed is we blocked the bottom of the core completely and no flow at all. Even when you have a case where you have high head loss, some flow will go through until -- in other words, we showed complete no flow at all.

If we blocked it at that point and had higher than the gravity head loss that's in there, what would happen if a small portion of the core was just remained open and that's the calculation we did.

CHAIRMAN BANERJEE: So you're saying that this mat does not extend over all holes that lead into the core?

MR. DINGLER: What I'm saying is seen from what we're -- what we saw --

CHAIRMAN BANERJEE: But you didn't see very much. You saw one test, this CDI test --

MR. DINGLER: We saw two, but --

CHAIRMAN BANERJEE: You couldn't even make out what the test was.

MR. DINGLER: Based on -- in other words, you look at the vertical head loss, the bed got compacted. You have high velocities. You look to the sump screen head loss. It got high velocities. The bed could compact.

Here, based upon the methodology in that, you had lower flows. The compaction of the bed would be less than what you see on the sump screens --

CHAIRMAN BANERJEE: Why? Sump screens were like .1 feet per second, right?

MR. DINGLER: And we saw some --

CHAIRMAN BANERJEE: And these would be about three centimeters per second by my calculation, right?

MR. DINGLER: And the screens --

CHAIRMAN BANERJEE: It's about .1 foot per second, right?

MR. DINGLER: If you saw the screens with that low velocity, the head loss on the screens didn't compact that much either.

CHAIRMAN BANERJEE: Well, the .1 feet per second, I seem to remember there were tests where we got enormous pressure losses.

MR. DINGLER: That's on the vertical head loss which is slightly different than --

CHAIRMAN BANERJEE: What's the difference?

MR. DINGLER: Vertical head loss is the gravity of the water will also compact that bed.

CHAIRMAN BANERJEE: But there is water on both sides of this bed, isn't there?

MR. DINGLER: Not necessarily on a regular head loss test, there may not be, no.

CHAIRMAN BANERJEE: Well, all right. Let's move on. But I'm not convinced that these are extreme calculations.

MR. ANDREYCHEK: Okay. Two sets of calculations were performed. One was blockage at the core inlet and the other one was LOCA fuel rod blockage or blanketing calculations.

DR. WALLIS: Why did you pick 99.4? Simply because that's one assembly?

MR. ANDREYCHEK: That's correct.

DR. WALLIS: And I figured out that the velocity there, you got 300 gpm going through about a 6,000ths of 50 feet square but it's still a trickle. It's still only about a couple feet a second or something, even through this one assembly, to get enough water in to cool the core.

CHAIRMAN BANERJEE: You need an average of three centimeters per second to get enough water in.

DR. WALLIS: It's too high for my -- well, --

CHAIRMAN BANERJEE: Well, if we can --

DR. WALLIS: It's --

CHAIRMAN BANERJEE: That's with 50 square foot of open area.

DR. WALLIS: If you plot 99.4 percent, you got a thousand sixths of that which makes quite a big number in your calculation.

CHAIRMAN BANERJEE: Yes. Well, we have to look at this carefully.

DR. WALLIS: That isn't enough from the down come of the supply. So, it would be good if you could tell us some things like this. This makes it clear. It only has a velocity of three feet a second. That's easily supplied by the head and the downcomer. That would really help.

CHAIRMAN BANERJEE: It's about six feet per second.

DR. WALLIS: Six, is it? I got two. So, we can --

CHAIRMAN BANERJEE: It's of that order.

DR. WALLIS: Let's say it's four.

CHAIRMAN BANERJEE: Take an average. All right. Keep going.

MR. ANDREYCHEK: Okay. A blockage of about 99.4 percent of the core inlet area was evaluated and the evaluation demonstrated that there's negligible impact on clad temperature.

DR. WALLIS: So it squirts in through one place and then it spreads through the core?

MR. ANDREYCHEK: Very quickly, yes.

DR. WALLIS: All right.

MR. ANDREYCHEK: The open lattice fuel structure.

Next. What we were looking at was a double-ended guillotine break and we had to run this from the very beginning to set up the appropriate thermal hydraulic conditions at the time of switch-over.

Fueling water storage tank can be depleted and self-recirculation begun within about 20 minutes. Fibrous and debris and particulates can pass through the sump screen starting at about 20 minutes after the initiation of the break and there is potential for some build-up at the core inlet.

MEMBER CORRADINI: So, if I might ask a question here. So, just for clarification, so the switch-over point's at 20 minutes.

MR. ANDREYCHEK: That's correct.

MEMBER CORRADINI: And then you assume what for the particulate and debris or at this point, you just say that's the point where I'm going to worry about the decay heat and all the associated stuff, and then you back out what you might want to pile on top?

MR. ANDREYCHEK: Actually, we don't care what the blockage material is. We --

MEMBER CORRADINI: You parametrically address that?

MR. ANDREYCHEK: Exactly.

MEMBER CORRADINI: Okay.

MR. ANDREYCHEK: That's correct. I'll get to that in the next slide or two.

Next slide, please. What break did we look at? We looked at a double-ended guillotine break and this slide describes the reasoning behind it.

We get the low flow rates and the low driving head. With a hot leg break, you get the full flow pump through there and if you need these, since you have cool legs intact, you can build water pressure back up into the steam generating --

DR. WALLIS: It doesn't matter what the break was. I mean, you simply got this downcomer head putting stuff through the core.

MR. ANDREYCHEK: Well, --

DR. WALLIS: It doesn't really matter how you got to that state.

MR. ANDREYCHEK: Well, you could get a higher driving head with the hot leg break.

DR. WALLIS: Well, that's obviously even better.

MR. ANDREYCHEK: Yes, so we wanted to pick the worst case.

DR. WALLIS: Yes.

MR. ANDREYCHEK: And that was the cold leg break.

Next.

CHAIRMAN BANERJEE: And the cold leg break, as you point out, there's a lot of stuff that's spilling out of the break, right?

MR. ANDREYCHEK: That's correct.

CHAIRMAN BANERJEE: But eventually, if it gets re-entrained and back, the fine things, it doesn't matter because --

MR. ANDREYCHEK: That's correct.

CHAIRMAN BANERJEE: -- it's over a long period of time.

MR. ANDREYCHEK: That's correct. But for

the purposes of this calculation, the recirculation -- we don't take credit for the recirculation and the re-entrainment of stuff, of chemical debris and particulates in this calculation. I'll get to that in just a minute.

CHAIRMAN BANERJEE: Okay.

MR. ANDREYCHEK: Next, we looked at what kind of a plant we wanted to look at. We were looking at a down flow plant, so that all of the flow had to come in and go down into the lower plenum and turn and go up with whatever debris it would have been carrying.

Next slide. We looked at the B&W and CE designs and again we found that the Westinghouse down flow plant --

CHAIRMAN BANERJEE: Just in your previous slide, I had a question. These holes in the baffle wall, --

MR. ANDREYCHEK: Yes?

CHAIRMAN BANERJEE: -- how large are they?

MR. ANDREYCHEK: On the order of about two inches.

CHAIRMAN BANERJEE: And the fuel is right behind it or is there a gap there?

MR. ANDREYCHEK: The fuel is close by it, yes.

CHAIRMAN BANERJEE: Close by.

MR. ANDREYCHEK: Yes, small distance.

CHAIRMAN BANERJEE: Yes. Okay.

MR. ANDREYCHEK: Okay. Let's go to the next slide, please. Okay. Again we chose the Westinghouse down flow plant design.

DR. WALLIS: So in that case, the debris forms on the top? Is that where it goes or am I misunderstanding? What does a down flow design mean?

MR. ANDREYCHEK: Down flow design means all the water that comes in goes down, the downcomer, and then turn and goes up into the --

DR. WALLIS: So it's down flow in what sense? In the downcomer?

MR. ANDREYCHEK: In the down -- well, --

DR. WALLIS: Okay. That helps. I thought you meant down flow in the core.

MR. ANDREYCHEK: No.

DR. WALLIS: I couldn't figure that out at all.

MR. ANDREYCHEK: No. It's in the downcomer.

CHAIRMAN BANERJEE: So, I'm still trying to imagine these holes in the baffle wall. You've got them. So, imagine the core inlet is blocked now and all the flow is going through these holes into the core region, bringing in debris. So, you're piling up debris in the outer rings of the fuel and these gaps are like what, 100 mils?

MR. ANDREYCHEK: I don't have an exact number but that's a reasonable number.

CHAIRMAN BANERJEE: On that order. So you're stockpiling the stuff up till the level reaches the baffle and then it -- there's so much debris that it doesn't take very much.

DR. WALLIS: There is not much debris at all.

CHAIRMAN BANERJEE: Well, if that's true, then it's not a huge amount of debris.

MR. ANDREYCHEK: Based on the information that we have, --

CHAIRMAN BANERJEE: Truckloads of debris coming in, right?

DR. LANDRY: Sanjoy, these baffle holes are not a concern in this analysis because we are not giving credit for them. When we looked at the designs, we said that we would not give a credit for flows through the baffle holes unless a plant could come in and show that they could guarantee those holes would not plug.

CHAIRMAN BANERJEE: Okay. Good.

DR. LANDRY: So, we've already said that. We're taking them out of the picture.

Now, those baffle holes do exist and they have been a problem for us in other areas, such as fuel fretting. That's not associated with this. This is another issue, but if you followed operating experience, those baffle holes have caused problems in other areas, but they do allow for flow into the core from the sides, but we are not going to give credit for that in these analyses.

CHAIRMAN BANERJEE: Good. Because he has a statement about this which is indicative that this is sort of like a back-up. It says, "Numerous large allow flow to bypass core inlet and block."

DR. LANDRY: That's in the WCAP. There's statements of this nature, but we have said in the SER that we are not giving credit for that, unless --

CHAIRMAN BANERJEE: Good.

DR. LANDRY: -- a plant can show that they can guarantee they won't plug up.

MR. ANDREYCHEK: That's right.

CHAIRMAN BANERJEE: All right. Thank you. That clarifies that.

DR. LANDRY: Okay.

MR. ANDREYCHEK: Next, please. Okay. So again, we chose the down flow plant. We looked at a core power density, extremely important to determine how the heat will be removed. We used an available three-loop down flow model plant rated at 2900 megawatts thermal which gave us a worst case condition for power skew to the top of the core, and I know this is very busy and very difficult to understand, but this is a schematic of the reactor vessel.

On the right-hand side, the left-hand side and the right-hand side was a nodal diagram of the COBRA TRAC model that we used.

CHAIRMAN BANERJEE: Could you explain that right-hand diagram a little bit because I couldn't figure it out?

MR. ANDREYCHEK: The purpose -- well, this diagram shows the reactor vessel modeling. If I were to look at -- can I borrow the --

DR. WALLIS: Each one of these things is a node?

MR. ANDREYCHEK: That's correct.

CHAIRMAN BANERJEE: And why are some of them sort of numbered with little circles with arrows?

DR. WALLIS: Those are cross flows, aren't they?

MR. ANDREYCHEK: That's correct.

CHAIRMAN BANERJEE: Those are cross flow nodes?

MR. ANDREYCHEK: It's symbols that we were using in providing best estimate LOCA methodology and COBRA TRAC calculations to show where cross flow would occur at and again it was an existing model and we borrowed liberally from it for this particular diagram.

CHAIRMAN BANERJEE: Why are some of these diagonal and why are they horizontal? Is there a methodology for selecting this?

MR. ANDREYCHEK: Yes, there is a methodology and it's described in an approved WCAP for use of COBRA TRAC for LOCA calculations.

MEMBER ABDEL-KHALIK: Now where radially is the open bundle?

MR. ANDREYCHEK: I will get to that in just a moment.

CHAIRMAN BANERJEE: So now the grid underneath that or whatever, these blocked-out areas right at the bottom of that, is that where the core inlet is or is it further up?

MR. ANDREYCHEK: Where the arrow is right now is where the entrance to the core is at. This is the lower plenum and the other lower plenum structures. This is the bottom of the core.

MEMBER CORRADINI: That is the grid plate or something down there, right?

MR. ANDREYCHEK: Yes, and this is the core region. This is the hot legs and the cold legs on either side up here. This is the core region up to here. This is the upper core support plate right here.

DR. WALLIS: So what saves you is the cross flow.

CHAIRMAN BANERJEE: Well, but where is the downcomer then?

MR. ANDREYCHEK: The downcomer is right here and here.

CHAIRMAN BANERJEE: And why is only half the downcomer noted on the right-hand side?

MR. ANDREYCHEK: It's a modeling or a figure -- it's the way the figure was drawn.

CHAIRMAN BANERJEE: So there are nodes actually across the downcomer in all directions, right?

MR. ANDREYCHEK: Yes, and if you give me a moment, I can show you where we are in the next slide.

CHAIRMAN BANERJEE: Okay. All right.

MR. ANDREYCHEK: Let's go to the next.

DR. WALLIS: Do you set up some sort of bulk circulation pattern in the core in this case? Do you have an output from this code that we can look at and see if it looks reasonable?

MR. ANDREYCHEK: I don't have it here right now, but I'm sure we can get it you something.

DR. WALLIS: I'm assuming it's not just the normal mixing cross flow, it's actually a bulk circulation that's set up.

MR. ANDREYCHEK: I couldn't answer that for sure.

CHAIRMAN BANERJEE: So this is primarily single phase. There's some boiling towards the top on this, right?

MR. ANDREYCHEK: That's correct. There is boiling at the top.

CHAIRMAN BANERJEE: How far in from the top?

MR. ANDREYCHEK: Approximately halfway in. It starts at about 20 minutes, maybe a little bit above that and towards the end of the 40-minute period, the boiling level rises a little further into the core as the mass inventory continues and the decay heat drops down.

CHAIRMAN BANERJEE: And above this -- so the onset of boiling is about halfway up?

MR. ANDREYCHEK: Approximately, yes.

DR. WALLIS: And then you boil over? Does the hot channel take this and act like a chimney and so there's splash liquid out the top which then spreads around on the top?

MR. ANDREYCHEK: I can't answer that because --

DR. WALLIS: It would help if we saw output from the core.

MR. ANDREYCHEK: That's fine, and again we can probably get you that. That's not specifically what we were looking for at this -- in this case. We were looking to see whether the peak clad temperature --

DR. WALLIS: But you're trying to establish credibility.

MR. ANDREYCHEK: What I --

DR. WALLIS: If you just say we did an analysis and the answer is X, then you have to establish credibility of the analysis which is done often by showing the details.

CHAIRMAN BANERJEE: Will they hang together because if they don't, I mean you could very strange results sometimes.

MR. ANDREYCHEK: We agree that on occasions when you run calculations, using a code, you will get strange results. The calculations that were done here were compared against the design basis calculations for this particular plant and found to be reasonable.

We did not provide that level of detail in the WCAP because it was --

DR. WALLIS: But if we looked at the details of your print-out, of your result, and you showed marked 3.5 in the hot channel, we might have a question as to how you could achieve that. So, it would be useful to see --

MR. ANDREYCHEK: I understand.

DR. WALLIS: -- what you're predicting.

MR. ANDREYCHEK: I understand.

CHAIRMAN BANERJEE: Or in --

MR. ANDREYCHEK: I understand, but again those were done in -- those checks were done internally to Westinghouse and the results were found to be reasonable.

Again our intent was not to provide a

detailed COBRA TRAC calculation but to see whether or not we could --

DR. WALLIS: No. Your objective is to convince us that you're believable. Your objective isn't just to get a number.

MR. ANDREYCHEK: Okay. Understood, understood.

CHAIRMAN BANERJEE: And the problem here is that if you tweak a knob here or tweak a knob there, you can change the answers a lot. That's the scary part. So, until you sort of look at how many knobs have been tweaked and which ones, you know, we don't know the sensitivity of these results to various assumptions.

MR. DINGLER: And I guess to speak for that, we didn't provide it. The NRC, in lieu of asking us to provide that data, they went ahead and did an independent verification that they'll talk about later on.

CHAIRMAN BANERJEE: Right. We'll wait for them, but you didn't do any sensitivity analysis?

MR. DINGLER: We compared it to what it was doing for the design basis for that plant, found out it was reasonable and met that criteria.

CHAIRMAN BANERJEE: What do you mean by

the design basis for that plant?

MR. ANDREYCHEK: Again this calculation was based using a model that was used for a design basis calculation --

CHAIRMAN BANERJEE: A specific plant?

MR. ANDREYCHEK: -- for a currently licensed plant.

DR. WALLIS: But the conditions are completely different.

CHAIRMAN BANERJEE: No, they're doing long-term cooling, basically, right?

MR. ANDREYCHEK: That's correct. That is correct. Bear with me, and let me go into the next step and I can show you where the "differences" occur at between what a design basis calculation is and where we are for the long-term core cooling.

CHAIRMAN BANERJEE: Okay. Go ahead. You want to use this place where you are or you want to --

MR. ANDREYCHEK: I'm going to use this for just a moment.

CHAIRMAN BANERJEE: Oh, because you can point to things.

MR. ANDREYCHEK: Yes.

CHAIRMAN BANERJEE: All right.

MR. ANDREYCHEK: Yes. So, a version of

the code was created which allows us to ramp up the hydraulic resistance as the code is running at a specified time and we did that in the first node of core channels where flow would be going into the core. The blockage cases were run to 40 minutes.

DR. WALLIS: And you only did this high K in all the channels except one?

MR. ANDREYCHEK: Actually did it in two cases.

DR. WALLIS: I know, but the 99.4, you had an enormous K everywhere except in one channel?

MR. ANDREYCHEK: That's correct.

DR. WALLIS: Okay.

MR. ANDREYCHEK: And again as Dr. Wallis noted, the blockage went to -- from the normal standard rate of about a K factor of 1.5 to 1 times 10 to the 9^{th} over half of a minute, 30 seconds, at the time of switch-over.

CHAIRMAN BANERJEE: But you didn't do all the channels going up to 10 to the 4 or 10 to the 5 or something? In other words, you didn't do a case where you have a uniform mat which may have resistance?

MR. ANDREYCHEK: We did not do a case where all channels --

CHAIRMAN BANERJEE: But you calculated --

now --

MR. ANDREYCHEK: We did not, no.

CHAIRMAN BANERJEE: -- there are correlations which are therefore pressure drop across mats, right?

MR. ANDREYCHEK: I'm sure there are, yes.

CHAIRMAN BANERJEE: You didn't put those in --

MR. ANDREYCHEK: No, sir, we did not.

CHAIRMAN BANERJEE: -- on the code?

MR. ANDREYCHEK: We did not, no.

CHAIRMAN BANERJEE: Okay. All right.

MR. ANDREYCHEK: We also changed the temperature of the RHR heat exchanger outlet which was feeding the core to approximately a 100 to a 190 degrees F which was what we would expect to see from a heat exchanger taking suction from the containment sump at that time and there was some margin added to that.

We looked at two cases, one where the loss coefficient was ramped up to over 92 percent of the flow channels and the other one, as Dr. Wallis noted, 99.4 percent of the channels or only one open fuel assembly.

MEMBER CORRADINI: So just to be clear,

the one that's 82 is 36 open assemblies along the periphery?

MR. ANDREYCHEK: That is correct.

CHAIRMAN BANERJEE: So, why did you consider these two as being extreme cases rather than just a uniform mat? This is what I'm not getting. You know, because that's what you see on small screens that you get sort of a mat. Maybe it blows through here and there. Why didn't you take that as a case?

MR. ANDREYCHEK: We chose not to take it as a case, and the idea was to see whether we could block off -- how much of the core we could block off and still get enough water through an open flow channel to demonstrate core cooling.

MR. SCOTT: I see your point. Okay? I mean, it's clear, if a bed, a uniform bed of debris could form over the entire strainer, then that would be worse, I presume, than if a bed formed over 99.4 percent of the strainer and left a hole. That's your point.

CHAIRMAN BANERJEE: I don't know that. I don't know the answer to that.

MR. SCOTT: I would assume it to be the case and we either answer that today or we've got a look-up on it, and I'm going to wait and see what the staff says about it, but as I see it that's your question.

CHAIRMAN BANERJEE: Because the rationale there is for relatively small screens, now the amount of debris that gets through is relatively small here, so I don't know whether there'd be big open areas or not, but for small 50 square foot screens, we've seen fairly high blockage.

MR. SCOTT: We either show that the situation you're talking about won't occur or --

CHAIRMAN BANERJEE: Right.

MR. SCOTT: -- we have to look at it and so again I don't know off the cuff what the answer is, but hopefully we'll hear from staff.

CHAIRMAN BANERJEE: Okay.

MR. KRESS: In a calculation like this, if you put it on uniformly, you have no idea when you plug 99 percent of the core. You have no way of knowing. If you put it in the way they do it, they can say now if we know we've blocked 99 percent of the core, but if you put it on uniformly, you don't have a measure of how much of the core you've blocked and I don't see how you can do that.

DR. WALLIS: But the charts that are blocking the whole thing are more likely than the extraordinary case where you block everything except one.

MR. KRESS: Well, the only thing you could do is come up with, say, the equivalent K --

DR. WALLIS: That's right.

MR. KRESS: -- for the whole core, but that's artificial. That's --

MEMBER CORRADINI: They would have to solve it by -- I mean, if I were on their side at this point, I'd say this is an extreme case because I have a pinhole somewhere in 217 assemblies and it's got to move laterally versus having many smaller pinholes uniformly.

DR. WALLIS: Another thing to do is to say let's block the whole core, find out how big K needs to be to get into trouble and show that can never happen.

CHAIRMAN BANERJEE: That's exactly the question asked right at the beginning.

MEMBER CORRADINI: But that, I can gather, they haven't said it, I'm surprised they haven't, that takes some iteration on what the K is. That's what Tom's getting at.

DR. WALLIS: So run the code a few times.

CHAIRMAN BANERJEE: But also, Mike, these resistances are fairly non-linear things because if you look at the correlations, it's -- but I can program that into a loss coefficient in the code.

MR. SCOTT: The logical basis of this argument, I believe, is that you will not get enough debris to experience a uniform bed of this sort. So, what you have not heard from us is how we know that's the case.

DR. WALLIS: Yes, how do you know that's the case?

MR. SCOTT: I understand the question.

CHAIRMAN BANERJEE: And I guess what Graham was working out is if you've got five cubic feet and 50 feet squared open area, you've got a couple of inches, if you put it down uniformly.

MR. ANDREYCHEK: And that assumes that the -- only the open area is the one that's covered because if you basically look at what you've got on the -- at the open -- at the flow -- the total cross-sectional area and the fuel was a 100 square feet approximately, --

CHAIRMAN BANERJEE: Right. So take half that, doesn't really matter.

DR. WALLIS: Why did it say 50?

MR. ANDREYCHEK: That was for the open

area in the fuel.

CHAIRMAN BANERJEE: So if you take a 100 square feet --

DR. WALLIS: Wait a minute. What's the difference? Tell me.

MR. ANDREYCHEK: The difference is the difference between a 100 square feet and the 50 square feet --

DR. WALLIS: It's a 100 square feet until it gets to the fuel?

MR. ANDREYCHEK: That's correct.

DR. WALLIS: Well, isn't that what matters, what grid space there is?

MR. ANDREYCHEK: Actually, you're getting material, as the photographs that were circulated this morning show, collecting on the bottom nozzle.

DR. WALLIS: Yes, but if it were the grid space, I'm just saying what's the worst case I can imagine? It is that the Germans were right and it goes to the grid space and it's uniform everywhere. If you can show that's no problem, then that's the extreme case. All this argument about we think this is good enough is a judgmental thing.

CHAIRMAN BANERJEE: I think we should move on because we know what they've done and there's an issue as to whether these are extreme cases or not and we'll table that and let's see the results of those.

MR. KRESS: Even though we know what they done here, I think it would matter where you put that code. It might be worse near the edge than near where you put it. So that might be another issue.

DR. WALLIS: It has to get to the hot channel somehow.

MEMBER MAYNARD: One other along the same lines. Does it make any difference if it's a large number of, say, quarter inch holes versus just one hole and one assembly?

MR. KRESS: That would be another way to look at it.

MEMBER MAYNARD: That's probably more likely the case. There'd be a lot of little holes around as opposed to just one assembly being uncovered.

CHAIRMAN BANERJEE: I think anything that goes in there will mix radially because of just gravity heads. The flow rates are so small, so there will be cross flow which will take care of it, and this is just a gut feel.

So, the real question is how much gets in? I mean how much water can get in?

MR. ANDREYCHEK: Okay. This photograph just shows the standard loading scheme, shows the lower plenum, the baffle barrel region. This is the downcomer region around the outside.

This model shows that we kept the peripheral channel open and blocked the center of the core and in this case, we had one channel open and we blocked the rest of the core, maintained the containment pressure of the atmospheric conditions by at the time of switch-over to the sump recirculation. We extrapolated the pressure versus time table from a best estimate LOCA analysis for the plant that we used as the input model.

I grade this little bit, hopefully to try to demonstrate and show the green line which was the vessel mass, and you can see the vessel mass is increasing over time for both --

DR. WALLIS: It's the same for both cases, isn't it?

MR. ANDREYCHEK: It's not exactly the same but it's very similar.

CHAIRMAN BANERJEE: What is the red?

MR. ANDREYCHEK: The red is at the time of switch-over from the injection from the fueling water storage tank or the boiling water storage tank to recircing from the sump, a 120 seconds -- 1,200 seconds.

DR. WALLIS: The two cases look the same. I looked through all these comparisons in the report and there's very little difference.

MR. ANDREYCHEK: That's exactly correct. That's the point that I wanted to draw. Thank you very much for bringing that up. That is, that regardless of the blockage that we looked at, we still got excellent core cooling. That's exactly the point.

CHAIRMAN BANERJEE: Only if you have enough water to cover the core.

MR. ANDREYCHEK: That's correct.

DR. WALLIS: What if something bad happens?

MR. ANDREYCHEK: That's correct. The next slide --

MEMBER CORRADINI: So just for clarification, --

MR. ANDREYCHEK: Sure.

MEMBER CORRADINI: -- so there is a difference after the red line. There's less inventory with 82 percent. So that means the monometer effect is that you've got a slightly larger downcomer water depth that's got to push against your K factor. Okay?

So just out of curiosity, did you ever check into what that difference in elevation is that has to offset the larger flow resistance?

MR. ANDREYCHEK: We maintained the water head difference the same, whatever the loss coefficient, the total loss coefficient, effective loss coefficient was across the core.

The next slide, I think, answers your question. What we see is that the integrated mass flow for -- you know, this is the boil-off rate down below here in the green, okay, and in all cases, both cases we looked at, we exceeded the boil-off rate, regardless of the blockage.

DR. WALLIS: Well, to answer his question, I mean you said earlier the K is 1.6 and the velocity is four feet a second or something. There's almost no Delta P at all to get the water into the core.

CHAIRMAN BANERJEE: You see, Mike, --

MR. ANDREYCHEK: It's different, it's slightly different.

DR. WALLIS: There is almost no Delta P.

MEMBER CORRADINI: But that answers your original question, though, Graham.

MEMBER ABDEL-KHALIK: Let me just ask an order of magnitude question. Let's say you're just going to push the boil-off, required boil-off flow rate through one assembly, 250 gpm. That is more than the flow rate through one assembly at full power conditions, is that correct?

MR. ANDREYCHEK: I believe that might be, yes.

MEMBER ABDEL-KHALIK: That's in fact more than 30 percent higher than the full power flow through one assembly, correct?

MR. ANDREYCHEK: I believe it is.

MEMBER ABDEL-KHALIK: Okay. So if that's the case, what is the normal pressure drop across the bottom nozzle up to the first spacer grid?

MR. ANDREYCHEK: I don't have that number in front of me right now. I do not have the number in front of me right now.

MEMBER ABDEL-KHALIK: So the question is would the natural driving pressure difference in that monometer be high enough to push the flow rate, that much flow rate which is 30 percent higher than the normal flow, power flow rate, through one assembly?

MR. ANDREYCHEK: Again, based on the calculations that we did and checking it, we were able to get at least the amount of flow we needed to match boil-off.

To answer your specific question, I did not do the checks. We didn't do the checks. I mean, you can argue it. We just didn't do it.

MEMBER ABDEL-KHALIK: Right. Any flaw in the numbers that I asked you about?

MR. ANDREYCHEK: I would have to check them. I don't -- you know, I haven't done the check calculations. You may have run them off, you know. I haven't done that. So.

MEMBER ABDEL-KHALIK: Four-loop plant, look at the flow rate per pump, multiply 250 by 217, you find out that that's higher than the normal full power core flow.

MR. ANDREYCHEK: We'll take a look at it. That's all I can tell you.

MEMBER CORRADINI: So, I am just listening to what you're saying, but there's not normal boil-off in the PWR. So, he's matching --

MEMBER ABDEL-KHALIK: No, no. I'm asking --

MR. ANDREYCHEK: He's looking for the head loss.

MEMBER ABDEL-KHALIK: -- do you actually have enough head provided in the downcomer to push that much flow through the first resistances that you will encounter in a single flow before you start getting --

MEMBER CORRADINI: I thought we already answered that.

DR. WALLIS: We answered that. It's a K of 1.6 on velocity of four feet a second. It's a tiny Delta P.

MR. ANDREYCHEK: That's right.

DR. WALLIS: If we believe the numbers as Tim told us.

MR. ANDREYCHEK: I haven't done the calculations, and I don't do real well.

CHAIRMAN BANERJEE: We can figure it out a different way.

MEMBER ABDEL-KHALIK: Okay.

MR. ANDREYCHEK: I haven't done the calculations and, you know, I don't want to say something that would not be correct.

MEMBER ABDEL-KHALIK: Okay.

CHAIRMAN BANERJEE: Okay. However, what you see is that green line and everything is very dependent on the integrated flow being above that green line. If the integrated flow falls below the green line, then all bets are off.

MR. ANDREYCHEK: May well be, yes.

CHAIRMAN BANERJEE: The issue is can it -- are there realistic scenarios where the blue or the dotted line can fall below the green line? That's really the issue.

MR. ANDREYCHEK: And I would suggest that at 99 percent, 99.4 percent blockage, whatever that translates into an effective loss coefficient across the whole core, what we're seeing is that not only do we maintain a constant distance between the green line but we actually increase the mass into the core over time.

CHAIRMAN BANERJEE: Obviously if you have some excess flow building over time, so that they converge, but I think the issue is, you know, 99.4 is sort of an arbitrary number. We don't know. At 99.9, you might get all below that, who knows. We have no idea. Sensitivity is unknown here.

I don't know where that turning point is. So, the real question is, and I think you asked this ad nauseam now, what is the resistance if you distribute it uniformly or otherwise, where you would fall below the green line, and then we have to judge whether this is realistic or not or are there any scenarios or what is the probability of getting such a thing or whatever, but right now, this seems fairly arbitrary, that you've just taken something and you've kept a periphery unblocked or in another case you've blocked it.

MR. SCOTT: Can I suggest we move on? We heard the question and we have it.

CHAIRMAN BANERJEE: All right.

MR. SCOTT: Okay?

DR. WALLIS: Can I present this? It would be nice to see the core with no blockage at all, which I suspect would still be just like the other ones.

MR. ANDREYCHEK: Yes, probably. Yes, I believe it would have been.

DR. WALLIS: We're still working on the report.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: Our rough calculation independently shows the velocities through single channel would be of the order of six meters per second.

DR. WALLIS: Meters?

CHAIRMAN BANERJEE: Yes. So this is --

DR. WALLIS: No.

CHAIRMAN BANERJEE: -- a left-hand calculation, right?

DR. WALLIS: 300 gpm for .3 square feet,

no way.

MEMBER BLEY: 20 square centimeters?

MEMBER CORRADINI: No, there's something wrong. This is boil-off with the latent heat vaporization. This is not CP Delta T. You're looking at the wrong end.

DR. LANDRY: Sanjoy, that number is not anywhere in the ballpark. The numbers that I have from when we did the analysis with TRACE, with 95 percent blockage, we are getting a core flow rate of 100 telegrams per second at a velocity of 0.226 meters per second.

CHAIRMAN BANERJEE: Now that is 99.4 percent.

DR. LANDRY: That's 95 percent blockage. That's completely off.

MEMBER ABDEL-KHALIK: We are not talking about core average velocity. We're talking about the velocity at the inlet through the open bundle.

DR. LANDRY: This is the inlet boundary velocity.

CHAIRMAN BANERJEE: Why don't we table this because we're talking different numbers?

DR. WALLIS: What was your number?

DR. LANDRY: .226.

CHAIRMAN BANERJEE: What Dave got is maybe a number which we can check later.

DR. WALLIS: This isn't through the -- this is the 100 feet of -- 100 square feet, not the 50 square feet. This is down below. This isn't in the grid.

DR. LANDRY: This is the inlet for a 95 percent block.

DR. WALLIS: This is before you get into the rods?

DR. LANDRY: Correct.

DR. WALLIS: So it's double. If you get into the rods, you get .44. That's about right.

DR. LANDRY: This is the velocity coming in.

CHAIRMAN BANERJEE: Okay. Let's leave this subject for now because I don't think we're going to resolve it on the fly, and the indications from these calculations certainly are the velocity's much lower. So, let's carry on. Do we need to -- go ahead.

MR. ANDREYCHEK: Okay. The summary of the blockage calculations show that we do get excessive flow into the core above boil-off rate and that there's very little difference between the two blockage cases that we looked at and we get a total core mass increase over the next 20 minutes after we assume arbitrarily that we ramp up this blockage over 30 second period and in actuality, this blockage would occur over a much larger period of time.

Should it occur, based on the debris concentration in the flow that's being delivered to the bottom of the core and the rate of efficiently capturing the debris by the assemblies and at the core inlet.

CHAIRMAN BANERJEE: Okay. So, let's go on to the --

MR. ANDREYCHEK: We looked at local blockage and it played out. Again, we looked at two phenomena, reduction of flow at a fuel grid and precipitation of chemical products on the fuel surface. We looked at a range of thermal conductivities for the precipitation and again this is consistent with, in part, the table that was presented earlier in the presentation. We looked at the minimum value of .1 BTU per hour per foot degree Fahrenheit and the maximum value of about .9.

Again the purpose of the parametric study was to look to see whether we're getting --

DR. WALLIS: I didn't understand Chapter

4 at all. You have a pie-shaped piece of a 12-foot long rod. I couldn't understand what was happening at all.

CHAIRMAN BANERJEE: There was no diagram.

MR. ANDREYCHEK: Okay. All right.

CHAIRMAN BANERJEE: It was very hard to interpret.

MR. ANDREYCHEK: Okay.

DR. WALLIS: There were funny statements about no convection occurs under the grid. I didn't understand what the model was at all. Sorry.

MR. ANDREYCHEK: Okay. Point taken.

CHAIRMAN BANERJEE: Do you have an ANSIS report on this which shows the details?

MR. ANDREYCHEK: We have a calculation that shows the details, not a report per se, but written up in a calculational form.

CHAIRMAN BANERJEE: They must have generated gridding and stuff when they did the answers. I mean, typically, they can display the gridding. It would be nice to see how they gridded it and what they actually did.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: Because it was very unclear from this.

MR. ANDREYCHEK: Okay. Point taken. And again we were looking at maintaining the predicted clad temperature less than 800 degrees Fahrenheit in all cases.

CHAIRMAN BANERJEE: So, you primarily used ANSIS as the heat conduction through here --

MR. ANDREYCHEK: That's correct.

CHAIRMAN BANERJEE: -- rather than a stress analysis?

MR. ANDREYCHEK: That is correct. Used the thermal elements.

CHAIRMAN BANERJEE: And you just put some sort of boundary condition which was a heat transfer on the outside.

MR. ANDREYCHEK: That's correct. And we applied elements to the surface to simulate the deposition materials.

CHAIRMAN BANERJEE: Why did it need answers? This is almost -- I mean, it's virtually a hand calculation.

MR. ANDREYCHEK: I agree with you. We were looking at doing some other things. We developed a model and we chose to simplify the calculations.

MR. KRESS: What did you use for the surface conditions?

MR. ANDREYCHEK: The heat transfer material -- the heat transfer conditions, we used for the surface conditions, we extracted from the COBRA TRAC calculations. We looked at heat transfer coefficients from the surface of the fuel rods.

MR. KRESS: Davis-Belter equation?

MR. ANDREYCHEK: Say again.

MR. KRESS: The Davis-Belter equation?

MR. ANDREYCHEK: Could be. It was also boiling.

MR. KRESS: Did it overflow?

MR. ANDREYCHEK: Well, we looked at boiling and steam, so we were looking at something on the order of around an H of somewhere close to 700 BTU per hour foot degree per square foot degree Fahrenheit.

DR. WALLIS: Well, it said no coolant flow through the interstitial region between the grid strap and the fuel.

MR. ANDREYCHEK: That's right. We assumed that there was nothing there.

DR. WALLIS: Nothing is coming through the grid?

MR. ANDREYCHEK: Exactly right.

DR. WALLIS: So, where does the water come from? How do you do the analysis?

MR. ANDREYCHEK: The cooling, the water goes around that portion of the grid that's blocked and it's supplied to the outside surface of the grid and we looked at actual conduction down the -- on either side of the grid.

DR. WALLIS: I didn't see anything about how you modeled the fluid mechanics. It seemed to be all about the rod. So, I was really mystified.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: It was just a conduction calculation.

MR. KRESS: It was both radial and axial.

MR. ANDREYCHEK: Say again.

MR. KRESS: It was both radial and axial.

MR. ANDREYCHEK: That's correct. We assume symmetry around the rod. That's why we used a quarter rod.

CHAIRMAN BANERJEE: So if I understand it, the grid was like a fin of some sort.

MR. ANDREYCHEK: Correct.

CHAIRMAN BANERJEE: And --

DR. WALLIS: So you're assuming there's no cooling by convection?

CHAIRMAN BANERJEE: On the outside of it, there was. The gin was --

MR. KRESS: There was a fin.

DR. WALLIS: You are going to clarify all that stuff.

CHAIRMAN BANERJEE: It really needs a diagram to show.

MEMBER ABDEL-KHALIK: I mean, your Slide Number 48 says that there is no axial conduction.

MR. ANDREYCHEK: That's a different model we were looking at.

CHAIRMAN BANERJEE: This is ANSIS model.

MR. ANDREYCHEK: That's correct. The ANSIS model didn't take into account actual conduction.

MEMBER ABDEL-KHALIK: Now how much does the heat transfer coefficient that you used in the calculations change when you change the layer thickness?

MR. ANDREYCHEK: We did not change the heat transfer coefficient on the outside surface. We kept it the same.

MEMBER ABDEL-KHALIK: So, if, for a given heat flux of the change in temperature that you report is simply a change in the temperature drop across that layer?

MR. ANDREYCHEK: That's correct.

MEMBER ABDEL-KHALIK: And you're telling me at a heat flux of 5 times 10 to the 3rd BTUs per hour per square foot, the change -- the temperature drop across that layer is 460 degrees F?

MR. ANDREYCHEK: Well, can we get to there? You're looking a little bit ahead, I believe. If you'll bear with me, let me get to that slide in due time and we can address that question.

CHAIRMAN BANERJEE: Yes, we are still at the ANSIS calculation here. Okay. So, I think you've answered it and we need some clarification, but let's move on past the ANSIS then.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: Are there any results you want to show us from the ANSIS calculation?

MR. ANDREYCHEK: I think the results are summarized in the report. I was going to focus on the --

CHAIRMAN BANERJEE: Carry on then.

MR. ANDREYCHEK: Okay. Basically the dimensions of the fuel rod that we were using in both the ANSIS model and the single radial dimension heat transfer model that we're going to talk about a little bit later.

DR. WALLIS: I didn't understand that when you were going to see if the rod heated up in some spot, you had to look at its whole length. I just had no idea why you did that.

MR. ANDREYCHEK: Again, at the time we were doing the ANSIS model, it wasn't clear what we were going to do. We figured we'd model the whole rod.

CHAIRMAN BANERJEE: There's a different heat flux.

DR. WALLIS: Yes, when the heat flux is a maximum and the crud thickness is a maximum, you have the maximum temperature.

MR. ANDREYCHEK: That's right.

DR. WALLIS: Who cares about the length of the rod?

MR. ANDREYCHEK: Again, we were looking at other applications and we were -- we modeled the whole rod.

CHAIRMAN BANERJEE: If the maximum heat flux was in the region where there was no crud, then it would make a difference. But anyway, carry on.

MR. ANDREYCHEK: Again, we were looking at crud thickness and what the crud thermal conductivity was for the models that we were using.

DR. WALLIS: This is a little homework problem on the next slide.

MR. ANDREYCHEK: Yes, it is.

CHAIRMAN BANERJEE: But the crud would deposit in the boiling region, right, and most of this other stuff --

MR. ANDREYCHEK: The chemical material would deposit in the boiling region. What we took in this case for this simple one-dimensional model was a series of worst case conditions. We had the clad, the oxide thickness, the crud level, and then we clad the chemical materials on top of it. So, we had a --

CHAIRMAN BANERJEE: This is like a worst case calculation?

MR. ANDREYCHEK: That's correct. That is correct. The bounding calculation.

CHAIRMAN BANERJEE: But you kept your heat transfer coefficient the same outside no matter how thick this became?

MR. ANDREYCHEK: That is correct. Furthermore, we also kept the heat flux on the inside surface equal to what would have occurred at the time of switch-over, 20 minutes, which is a conservatively high number.

CHAIRMAN BANERJEE: Right. But wouldn't

the heat transfer coefficient in the gaps as this stuff was building up become lower than --

MR. ANDREYCHEK: It might change. It would change. Well, I would expect it to go up which would provide --

CHAIRMAN BANERJEE: Up or down?

MR. ANDREYCHEK: I would expect it to -- the heat transfer coefficient to actually go up because if it's -- you're accelerating the flow in that region. You have less flow area, so the velocities would be higher. I'd expect to see greater convection.

CHAIRMAN BANERJEE: But why wouldn't the flow just divert itself through the open areas?

MR. ANDREYCHEK: Again, if we're looking at boiling in a cold leg break situation, you've got relatively uniform boiling across the entire core.

CHAIRMAN BANERJEE: I know that, but if I look at the subchannel --

MR. ANDREYCHEK: This was not a subchannel analysis and neither was COBRA TRAC a subchannel analysis. That was beyond the scope of what we were dealing with.

CHAIRMAN BANERJEE: You're looking at a uniform rod, but the fact that in the gap regions we have a smaller interstitial space and therefore -- I mean eventually the gap closes. We have no heat transfer.

MR. ANDREYCHEK: There's no convective heat transfer and again understand that this was not an attempt to try to predict what kind of deposition you would get. It was let's see whether or not we can get to 800 degrees Fahrenheit if we take a look at convection on the outside surface.

CHAIRMAN BANERJEE: So, if you actually -- I can imagine that the gaps would close. Would that be enough circumferential conduction to keep the temperatures down then or axial conduction or what would take care of that?

MR. ANDREYCHEK: We didn't try to get to that extent because again using the LOCADM spreadsheet calculation, we wanted to find out how much deposition we'd get and what we've seen so far is approximately 10 to 12 mils additional deposition from the chemical effects which is far away from 50 mils deposition that would tend to block the channel or give you rod to rod bridging of material.

So, from what I know of these calculations and looking at them, I believe that this calculation is reasonably applicable for the time -- for the range of conditions we're looking at at this point.

CHAIRMAN BANERJEE: All right.

MEMBER ABDEL-KHALIK: So tell me where I'm off. You're using decay heat after 20 minutes?

MR. ANDREYCHEK: That's correct.

MEMBER ABDEL-KHALIK: Right?

MR. ANDREYCHEK: That's correct.

MEMBER ABDEL-KHALIK: And that corresponds to a peak heat flux roughly 2 percent --

MR. ANDREYCHEK: Approximately.

MEMBER ABDEL-KHALIK: -- of hot spot which means a heat flux is what, 10 to the 4^{th}? So, if I take your maximum thickness and your lowest conductivity, I should get the maximum Delta T across that layer --

MR. ANDREYCHEK: Okay.

MEMBER ABDEL-KHALIK: -- and if I do that calculation, I get a 138 degrees F. So, why are you getting 475 or 470?

MR. ANDREYCHEK: The calculations for 50 mils of particulate and the minimum crud, minimum oxide gave us that from the simple radial heat transfer model that we had.

DR. WALLIS: Is this a hot spot? Is that what it is?

MR. ANDREYCHEK: Say again.

DR. WALLIS: Is that the hottest spot?

CHAIRMAN BANERJEE: No, no. It's just .1.

DR. WALLIS: This is at the hottest place, isn't it? Well, I'm trying to. I mean, it's how close do I need to get? Swallow it.

MR. ANDREYCHEK: Again, if I look at the maximum temperature of the cladding at this point, we're looking at about -- you're right. It's about 470 degrees. Okay.

MEMBER ABDEL-KHALIK: I have to add the 260.

MR. ANDREYCHEK: Yes, or subtract from it and that gets you the Delta T. That was what Mr. Wissinger just shared with me. He said we're not -- we're missing that step of looking at what is the temperature difference across and you've got about a 260-270 degree sink temperature. That gets you the 150 or so degree temperature that you're looking at. I think that answers your question.

MEMBER ABDEL-KHALIK: Right. Thank you.

MR. ANDREYCHEK: Sure.

CHAIRMAN BANERJEE: So the Delta T is of the order of 200 degrees?

MR. ANDREYCHEK: Maximum. It's actually

less than that.

CHAIRMAN BANERJEE: But if you, of course, touch the rods at 50 mils on each side, then essentially it can be anything.

MR. ANDREYCHEK: Again, the intent here was not -- was to look to see what temperatures you might expect as we come close to that point. We didn't try to evaluate or analyze what happens when you actually touch the rods because it was --

CHAIRMAN BANERJEE: Let me ask the question. If you did touch the rods --

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: -- with this, would there be enough circumferential conduction to take care of the problem or would you get a problem with that?

MR. ANDREYCHEK: I don't know.

CHAIRMAN BANERJEE: That, I think, is the relevant question.

MR. ANDREYCHEK: That's a fair question. We have not evaluated that.

CHAIRMAN BANERJEE: Because that at least gives you a scenario which is sort of like perhaps one that --

MR. ANDREYCHEK: No, we haven't --

CHAIRMAN BANERJEE: -- is axial or radial.

MR. ANDREYCHEK: We haven't taken credit for actual conduction nor -- again, and I can't stress this enough, looking at it in a bounding condition, --

CHAIRMAN BANERJEE: But this is not a bounding condition.

MR. ANDREYCHEK: Well, it is when we're saying that we're not going to get 50 mils of deposition and that's the point. I think we're going well beyond the point of where we would expect to be.

This was a simple parametric study. We didn't think we were going to get more than maybe 20 mils of deposition. The calculations were showing 10 mils. So, if we don't build there, how can we -- why do we need to look at that? It doesn't make any sense. It's a good homework problem, but it's not -- really doesn't -- that's not what we answered.

CHAIRMAN BANERJEE: Well, it depends on how sensitive the deposition is to the assumptions. You know, if --

MR. ANDREYCHEK: We bounded the deposition by assuming that whatever boils is deposited and that's a conservative assumption. So, we already are dealing with a conservative deposition.

We've got a very conservative model and --

CHAIRMAN BANERJEE: So whatever boils deposits. What happens if you've got aluminum hydroxide coming in and happily depositing?

MR. ANDREYCHEK: If aluminum hydroxide comes in and is deposited, then that's part of the equation. Whatever we -- whatever comes -- is carried into the --

CHAIRMAN BANERJEE: I'm just saying there are scenarios where I can imagine that deposit would be thicker than that because you'd have possibly a source of material which, when boiled off, would give you more of a deposit, right? Are there no scenarios where there can be more dissolved matter?

MR. DINGLER: At this point, based on the calculations DM LOCA that calculates the growth, the crud layers and all that we anticipate, we see no way to get above the 50 mils.

CHAIRMAN BANERJEE: No way at all?

MR. DINGLER: Unless you got severe accident and that's beyond our licensing basis.

CHAIRMAN BANERJEE: So, there is no dissolved chemicals which could deposit?

MR. DINGLER: Based on what we know today, --

CHAIRMAN BANERJEE: Is that --

MR. DINGLER: -- we don't see that.

MR. KLEIN: I think we can address that during our part of the presentation.

CHAIRMAN BANERJEE: Okay.

DR. WALLIS: The concern I had was if this deposition were preferentially in some places, so there's some kind of instability where it starts to grow in one place and it grows there and it doesn't deposit elsewhere, I just wondered if there were some conditions whereby you would deposit preferentially at the bottom when it first comes in or behind the grid space or something.

You shouldn't have all these uniform layers and that may well be reasonable, but it's conceivable that the crud would deposit preferentially because of temperatures and flow conditions in certain places. Now, I didn't see an answer to that.

MR. ANDREYCHEK: Well, --

CHAIRMAN BANERJEE: I see --

MR. ANDREYCHEK: -- the ANSIS model was intended to look at a preferential deposition of material, you know, behind a grid, over a two-inch high grid, and it did take into account actual conduction and we did see from the calculations that we were -- our temperature ranges were still of the same range that we're getting here in the figure I'm showing on Slide Number 49.

DR. WALLIS: Well, I was more concerned about not having, say, 50 mils everywhere but having 200 mils in some places and none somewhere else. That's the sort of thing I was concerned about.

MR. KRESS: Then you wouldn't have a fin.

MR. ANDREYCHEK: Yes. I don't know of any process or any phenomena that would cause that kind of a build-up in any one location. Furthermore, I would suggest that based on what I've seen, if I begin to get -- and this goes back to FLECHT-SEASET testing, if you begin to build up debris in one location, almost like a ballooning of a rod, you do tend to get some improvement of heat transfer downstream of that because of the --

DR. WALLIS: Well, if there were a positive temperature coefficient where the hotter it gets, the more deposition you get, then you might be in trouble.

MR. ANDREYCHEK: That's right.

DR. WALLIS: There's some chemistry which said that happens.

MR. ANDREYCHEK: Right. I don't see any reason for that to occur with what we've gotten with the types of chemical products we have right now.

MEMBER CORRADINI: I think, though, Professor Wallis, actually the way he's asking it, I think, is what I was thinking about, is non-uniformities that are driven by up the temperature gradient and if you can eliminate that from an argumentation standpoint, I think that kind of gets rid of the concern because you could have it preferentially go to the hot spot and then just aggravate the situation. I think that's what Graham was after.

DR. WALLIS: Sort of the idea of an instability that builds up preferentially in some places.

CHAIRMAN BANERJEE: But in fact the peer review group of the chemical effects pointed out that there was several materials that -- I don't know in this case if there will be, which had an inverse solubility behavior.

MR. KLEIN: That's correct. I'd like to add, too, there may be some confusion for -- I think what he's shown here now is sensitivity studies that assume uniform deposition, but the LOCADM code that's actually used to lay down the chemical scale, if you will, is dependent on the local heat flux.

So, it does put the larger deposit where you have boiling conditions and it deposits much faster than in non-boiling conditions.

MEMBER CORRADINI: Say it again. I apologize. Could you repeat that, please?

MR. KLEIN: There are several different codes that were used in the -- within the WCAP, what Tim is presenting here is a sensitivity study that includes chemical scale, but in that sensitivity study, they assumed a uniform deposit of various thicknesses.

When you run the LOCADM code for the plant-specific condition, it does account for higher deposition at hot spots.

CHAIRMAN BANERJEE: But that wasn't done here?

MR. ANDREYCHEK: No, it was not.

CHAIRMAN BANERJEE: You're asking them to do that?

MR. ANDREYCHEK: That's correct.

MR. KLEIN: There is a sample calculation in the WCAP that takes what we think is a very high fiber/high calcile plant and runs a LOCADM analysis and produces 10 mils of chemical scale.

MR. ANDREYCHEK: On the worst case rod.

CHAIRMAN BANERJEE: And you had the boiling regions or wherever?

MR. ANDREYCHEK: Yes.

CHAIRMAN BANERJEE: Okay.

DR. WALLIS: So, you say that calcium is one of those that has this inverse solubility?

MR. KLEIN: I think the retrograde solubility with calcium makes that one of the leading candidates for depositing within the vessel.

CHAIRMAN BANERJEE: And the 10 mil comes because there isn't enough calcium around or what is the reason?

MR. ANDREYCHEK: The 10 mils is what's predicted to be deposited as a consequence of the boiling as well as whatever is going on with the calcium in terms of retrograde solubility.

CHAIRMAN BANERJEE: And it's continuously being replenished, right? I mean, you've got a huge reservoir.

MR. KLEIN: That's correct. In the LOCADM code, you couple the concentration of the chemicals in the vessel with the concentration outside. So, as you locally deposit and deplete that concentration, you'll have more come in.

CHAIRMAN BANERJEE: And why -- what limits the process to 10 mils?

MR. KLEIN: I think the -- if you look at the amount of -- the period of time that boiling occurs, that is one of the major contributors to the amount of scale that's laid down.

CHAIRMAN BANERJEE: How long does the boiling occur for?

MR. ANDREYCHEK: The boiling will terminate once you go on to recirculation from the hot leg. As long as you're feeding from the cold leg, for cold leg break, you will have a tendency to have boiling, but once you go on to hot leg recirculation, you're putting water directly into the top of the core and that can occur anywhere from four, six hours, up to maybe nine, nine hours, and when you top flood the core and flush the core for boric acid precipitation concerns, you also terminate the boiling process, and at that point, that doesn't terminate the deposition but it reduces the deposition by a factor of about 1/80th.

So, your major deposition due to boiling occurs during the initial several hours immediately following the postulated accident.

CHAIRMAN BANERJEE: So, every plant flushes at some point?

MR. ANDREYCHEK: That's correct. That's how boric acid precipitation control is maintained. That's correct. There's a core flushing flow.

CHAIRMAN BANERJEE: Okay. So, are we on to your summary now?

MR. ANDREYCHEK: Yes. Okay. And again taken in sum total, information evaluation performed demonstrate that sufficient long-term core cooling is achieved for PWR to satisfy the requirements of 10 CFR 50.46 with debris and chemical products that might be transported to the reactor vessel and core by the coolant recirculating from the containment sump.

A blockage at the core inlet, top or bottom, does not occur. Fibrous debris is small in both volume and size. Defense in depth calculations and analyses demonstrate that if a large blockage does occur, core decay heat removal will continue. The collection of debris on fuel grids is -- we've evaluated that and we don't see that the temperatures build up to unacceptable levels and the same thing with collection of material on the cladding, based on the parametric studies that we've done, and therefore when considered collectively, the 10 CFR 50.46 long-term core cooling criteria are satisfied for the GSI 191 concerns.

In conclusion, any blockage at the core inlet that may form will be limited and when I say limited, I actually mean the depth, and will not be impenetrable to flow. The data on Page 11 of your handout is an indication of that.

Collection debris on fuel grids --

DR. WALLIS: This would help if you would quantify this, this is based on some estimate of how big the blockage could be and what effect it would have as a resistance instead of these blanket statements that it's limited and not impenetrable. That doesn't quantify how big it is.

MR. ANDREYCHEK: Okay.

DR. WALLIS: Or could be. That would help me if the text had some maybe estimates of how big it could be rather than saying it's not there or if it is there, it doesn't matter or something like that.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: Now these core-flushing flows, will they have any debris with them or not?

MR. ANDREYCHEK: They draw from the recirculation, from the sump. So, there's a potential for some debris in those -- in that flow.

I would suggest that when you take a look at that, typically given the ECCS flow rates that you would expect to see, the containment sump turns over in approximately 20 to 30 minutes post LOCA. So, by the time you begin to flush the flow from the top, you've already recirculated through the sump screen on the order of anywhere from eight times, maybe as much as 12-14-15-16 times. So, any debris that you would expect to see, particularly fibrous debris, is pretty much gone.

CHAIRMAN BANERJEE: Either on the fuel or the screen?

MR. ANDREYCHEK: Pardon?

CHAIRMAN BANERJEE: Either on the fuel or on the screen by then?

MR. ANDREYCHEK: It will -- if it's a cold leg break, it will be on the screen, most likely.

MEMBER MAYNARD: So, when this flow that you've been getting through the cold leg injection just now taking it through the hot leg?

MR. ANDREYCHEK: That's right.

MEMBER MAYNARD: But it's drawn from the same sump?

MR. ANDREYCHEK: Same.

MEMBER MAYNARD: Same system?

MR. ANDREYCHEK: So, --

DR. WALLIS: This is supposed to be something that the utilities can use to make their case. So, it seems to me it ought to have some methodology in it, so that if they do tests which I guess are going on about this bypass at the screen, if they find out that for certain sequences of injection of debris, they get 10 feet per thousand square feet instead of one, then they can make a calculation instead of saying there's no blockage or it's small. They have a way of calculating what it is and what happens if it's 10 times as much, that would be helpful to them, but these statements that it's minimal and so on don't help them if the parameters then change as a result of new evidence, do they?

You have to have a mechanism -- you have to have the methodology for calculating as the evidence changes.

MR. ANDREYCHEK: And the LOCADM code does address, as Mo had mentioned earlier, the LOCADM does address the deposition of fiber bypass on the fuel bump-up factor which is dependent upon bypass flow or bypass debris.

CHAIRMAN BANERJEE: So, I think we probably need to move on.

MEMBER ABDEL-KHALIK: Can I just ask a

question about applicability of methods?

DR. WALLIS: Are we going to move on to the staff?

MEMBER ABDEL-KHALIK: It's a basic calculation that you're doing where you're blocking the entry to all but one assembly. So, the geometry is essentially that the majority of the core is blocked, you have one hole at the bottom that's right below one assembly, and at that point the reactor cooling pumps are tripped, you're relying on natural circulation from the downcomer going into the lower plenum and up through that one hole and then presumably you have cross flow from that jet that's coming in from that one assembly to distribute the flow over the entire core.

You have boil-off. You have a free surface somewhere in the middle of the core. Is that the geometry that's being modeled?

MR. ANDREYCHEK: Yes.

MEMBER ABDEL-KHALIK: Okay. How well can your codes model that case?

MR. ANDREYCHEK: Help me understand what you're looking for in terms of how well they can model that case. I'm not sure exactly what you're looking for.

MEMBER ABDEL-KHALIK: I'm looking for whether or not your methods can actually model the cross flow that is happening which you are sort of totally dependent on to make your case.

MR. ANDREYCHEK: The cross-flow loss coefficients where they're used in the calculations are based on at normal -- the normal standard loss coefficients you would expect to see between rod bundles and as long as you're in single flow conditions, I would believe those are reasonably accurate and reasonably good to work with and that's where the flow goes -- is actually spread, is in the lower regions of the core.

MEMBER ABDEL-KHALIK: Have the codes ever been validated to model a geometry of this sort?

MR. ANDREYCHEK: I can tell you that, to the best of my knowledge, we've not gone through an extensive validation process on this for that particular specific geometry.

MEMBER ABDEL-KHALIK: But that is the geometry that you're modeling, correct?

MR. ANDREYCHEK: That is correct.

MR. DINGLER: But they have been validated without the blockage on the core.

MR. ANDREYCHEK: That's right.

MR. DINGLER: So that these are license basis codes we used to promote the codes.

MEMBER ABDEL-KHALIK: Yes, but you're now talking about blocking 216 assemblies and having one hole in the bottom right above one assembly and modeling the scenario.

MR. DINGLER: We agree with that, but what I'm saying is it was valid -- you get the impression that it was never -- the code was never validated. It is a valid code used for license codes. That's why we used it and we changed the parameters to block the bottom of the core. That's the only parameter change that we did.

CHAIRMAN BANERJEE: I guess the issue is about radial mixing, whether you can get it right or not, you're either overestimating or underestimating or getting it bang on, who knows, but in addition to that question, because these codes don't have cross-flow momentum to them, they just have loss flow --

MR. ANDREYCHEK: Let's think about that for a second, if I may address that question. You know, we're talking about not a lot of flow coming in, okay, and what we're talking about is maybe a pot yea big with a hole that big on the bottom and the flow that's coming in doesn't have to be very large. We're not talking about, you know, thousands of gallons per minute coming in.

Bear with me, please.

MEMBER ABDEL-KHALIK: 250 gallons per minute is still higher than the normal forced circulation flow through one assembly. It is not? How is that?

CHAIRMAN BANERJEE: Identify yourself, please.

MR. WISSINGER: Sorry. Gordon Wissinger from AREVA. When you were talking about that earlier, we looked at it. Normal flow is about 400,000 gpm.

MEMBER ABDEL-KHALIK: Right.

MR. WISSINGER: Okay. So, when you do this flow at 250 gpm --

MEMBER ABDEL-KHALIK: Times 217.

MR. WISSINGER: Right. It's like 38,000.

MEMBER CORRADINI: It's off by a factor. It's the latent heat versus CPTT.

DR. WALLIS: That's right.

MR. ANDREYCHEK: So, you are talking about a lot less flow. It's coming in and it can't help but spread out. Now we're not talking about what I would consider to be jet flow coming in. I think that's a mischaracterization of it. We're not talking about jet flow coming in and shooting to the top. We're talking about literally flow leaking in and spreading.

CHAIRMAN BANERJEE: It's not exactly a leak. It's coming in at least a meter per second but still.

MR. ANDREYCHEK: It's not a jet.

CHAIRMAN BANERJEE: But there is an issue here which has been bothering me. Suppose this flow brought with it now this entrained material. It's gone and matted around.

Wouldn't it form in the gaps deposits of debris?

MR. ANDREYCHEK: I'm not sure I understand.

CHAIRMAN BANERJEE: Okay. So, let's say you've got a mat and it's blown through somewhere. So, the mat has blown through and you've got a hole there, but now, of course, debris will come through that hole with the flow, and wouldn't that debris sort of get filtered out because the gaps between the fuel pins are so small, and wouldn't it sort of start to deposit at the bottom and slowly build up and prevent cross flow?

I mean, there's no experiments done, so

it's very hard to know.

MR. ANDREYCHEK: I'm not going to disagree with you on that account, but again this process --

CHAIRMAN BANERJEE: That's an experiment.

MR. ANDREYCHEK: That's right.

CHAIRMAN BANERJEE: The experiment you had done before, but now let's say you've blocked off most of that fuel rod and there's a hole in there and you just put a piece of paper or something down with a hole cut in it and let the stuff come through.

As it strives to go radially, would that deposit this junk and start to increase the radial resistances and by itself slowly build up this bed towards the top because as you block at the bottom, it will start to go in the top more and more? Are there phenomena like this that might occur?

MR. ANDREYCHEK: You know, I haven't looked at those phenomena. It's possible, but again this ends.

CHAIRMAN BANERJEE: The debris has to go somewhere, right?

MR. ANDREYCHEK: This ends when you go into recirculation from the hot leg because now you're flooding from the top and flushing whatever you had in the core down and out.

CHAIRMAN BANERJEE: Well, there are other issues about that as to whether the water will actually get down if you have debris. I mean, I don't know. What are the flow -- I mean, what -- if you start to block the top, now you just got a little layer of gravity, right?

MR. ANDREYCHEK: You can't have it both ways. I mean, if you're going to have water come --

CHAIRMAN BANERJEE: I'm going to have it both ways.

MR. ANDREYCHEK: Why wouldn't water carry debris back down? I'm not sure I understand this.

CHAIRMAN BANERJEE: Well, you just said that the down flow is worse than an up flow.

MR. ANDREYCHEK: I didn't say that.

MR. WISSINGER: In the baffle flow configuration, that is true.

CHAIRMAN BANERJEE: Sorry.

MR. WISSINGER: For the baffle flow.

CHAIRMAN BANERJEE: You are arguing about Argonne tests not being representative or something?

MR. ANDREYCHEK: Well, let's be careful because in the Argonne tests, if I understand it correctly and I may not, we're talking about a filter bed and you're dumping water on top of the filter bed.

Now, it's held by a screen in place. It's not going anywhere. If we're looking at what we have in the PWR, you're talking about a fiber bed building up, basically being held in place by whatever pressure the water brings to bear, trying to pull up through it, along with the particulates.

Now, you change the problem by saying I'm going to flood from the top. You have gravity working to pull it down as well as the water flow trying to pull it down.

CHAIRMAN BANERJEE: I am asking you what happens --

DR. WALLIS: The gravitational effect on that.

MR. ANDREYCHEK: I'm not disagreeing but you now have forces tending to want to move whatever is collected on the bottom of the fuel assembly and the bottom of the grid to pull it down and away.

CHAIRMAN BANERJEE: No. I'm just asking what would happen at the top. Suppose you had debris coming in with this water. Let's hypothesize.

MR. ANDREYCHEK: Okay.

CHAIRMAN BANERJEE: Okay.

MR. ANDREYCHEK: Now we're talking about when we go into hot leg -- I want a clarification.

CHAIRMAN BANERJEE: Yes, yes.

MR. ANDREYCHEK: Recirculation?

CHAIRMAN BANERJEE: You're going into the top.

MR. ANDREYCHEK: So, we're well out into the transient and we've already gone through a number of recirculations. So, the amount of debris, the amount of fibrous debris I'd have is very, very small.

CHAIRMAN BANERJEE: I'm not going to assume that. I'm going to assume that there's suspended debris still.

MR. DINGLER: I think what your scenario is is the upper plenum injection and we did discuss that.

CHAIRMAN BANERJEE: Yes.

MR. DINGLER: And that's the same as I believe what you're explaining because they do interject debris from the top and we evaluated that and found out that and determined that was not an issue that you're discussing about, and I believe the staff then looked at that, what we presented on that, also. I think --

CHAIRMAN BANERJEE: Are the holes bigger there or what happens?

MR. DINGLER: In other words, the upper --

go back to our slides on the upper plenum injection is you're injecting down through the core from the top.

CHAIRMAN BANERJEE: Okay. But there's some grid spaces at some point that come in, right?

MR. DINGLER: That's the upper plenum injection that has the same scenario what you just explained on there.

SPECIAL AGENT DVORAK: So now you've got a down flow through those -- that's up there. Why don't -- doesn't it correspond to the Argonne scenario then?

MR. ANDREYCHEK: For the upper plenum injection plants, flow is very, very large and for cold leg break, --

CHAIRMAN BANERJEE: Do you have more than the gravity head driving it now?

MR. ANDREYCHEK: Yes, you may have more than -- yes, you have more than --

CHAIRMAN BANERJEE: Do you have build-up at the top of the plenum and you have a pressure-driven flow?

MR. ANDREYCHEK: Yes, you may, absolutely.

CHAIRMAN BANERJEE: And what do you really have?

MR. ANDREYCHEK: It depends on --

CHAIRMAN BANERJEE: Do you have any void in the plenum?

MR. ANDREYCHEK: If the flow is sufficient, for cold leg break flow is sufficient, you will overfeed the break and you will build up a pressure head in the upper plenum based on water head in the -- water column in the upper plenum.

MR. SCOTT: Can I make a suggestion? I think you all want to hear from the staff. It's after 3 o'clock. I would suggest we move -- have a break and then move on to the staff's presentation at this point.

CHAIRMAN BANERJEE: Okay. We will take the suggestion and you'll tell us all about upper plenum injection at that point.

MR. SCOTT: We have a slide that will talk about it. Whether that will address your questions or not, I don't know.

CHAIRMAN BANERJEE: Okay. We'll take a break for 15 minutes.

(Whereupon, the meeting recessed at 3:12 p.m. and reconvened at 3:27 p.m.)

CHAIRMAN BANERJEE: We will go back in session then and it's over to you, Mike.

MR. SCOTT: Okay. Before Ralph and Paul

Klein get started, I'd like to take care of a couple of items and hopefully Graham will come back because he was part of these.

One is the question about the possibility of a bed of debris, a uniform bed of debris over the whole bottom part of the core, right, as opposed to a fairly arbitrary test that says, well, I've got 99.4 percent of the core covered and I've got a hole for the other part and your question was along the lines of has that been considered, and I have talked about that with Mo and Tim and Ralph and you want to speak to that or you want to wait on Mo to come back? Oh, he's back? Oh, okay.

CHAIRMAN BANERJEE: I should clarify that, Mike, by saying I'm not really suggesting that TRAC or whatever, COBRA TRAC or whatever they're using sort of calculation, but even hand calculation might suffice there.

MR. SCOTT: Well, what I'm being told is that there is not a calculation that could be used to do that quantitatively, but I'll let the WOG folks, PWR owners' group folks answer the question and then we'll provide potentially additionally perspectives.

MR. ANDREYCHEK: And the question, so I understand?

MR. SCOTT: The question regards have you modeled, have you analyzed the case of the core being completely -- the core inlet being completely covered by a bed of debris?

MR. ANDREYCHEK: We have not done that calculation. We've not done that model.

MR. SCOTT: And the reason you didn't think it was necessary was?

MR. ANDREYCHEK: Based on the data that we saw, the testing that we saw, we did not get a compressed bed of fiber that would create a substantial head loss across the bottom of the core for the preloadings that we would expect to see from the current plants. That was based both on two separate tests that we observed.

Certainly the data that I presented in the table this morning as well as in other tests that we had the opportunity to take a look at, we did not see a compressed fiber bed that would result in significant head loss over the debris-loading conditions that we would expect from the plant.

Mo?

MR. DINGLER: And that second test had calcium silicate as one of its main contributors to debris. So that was a high-particulate-loading plant and minimal fiber where the other plant was a high-fiber and low-particulate. So, we used both of those and both of those tests indicated very loose layer on the bottom that do not restrict the flow to a point that it would stop any flow or that coming through.

CHAIRMAN BANERJEE: Let me ask you a question. What is the head available to drive the flow through the core? How many psi?

MR. DINGLER: I don't know in psi, but I -- what is it?

MR. ANDREYCHEK: It's approximately six to eight feet in the downcomer.

DR. WALLIS: Six to eight feet?

MR. ANDREYCHEK: Yes, six-eight foot in the downcomer, depending upon the time past the LOCA that we're dealing with. With regards to a hot leg break, you could get upwards of around 60 to 70 feet of head by virtue of flooding back up into the steam generator.

MR. SCOTT: So let-- just to be clear here, the CDI evolution that you were informed about in the earlier presentation, based on my observation, likely had complete coverage of the bottom of the fuel assembly that was tested with a very fluffy bed of debris. Okay? So that was tested.

However, we don't have an analysis, a computer analysis and I'm told you really can't design one like that because of the way it was done. I mean, you don't really -- I don't think we assume that we have a core that has 99.4 percent fully plugged up and the other zero. I mean, I don't think that's a physically representative thing.

This is simply a what happens if we took that much flow away, that percentage of the flow and the way the computer code works is, is you take, you know, a block and you leave it open and all the rest are closed. I don't think that was intended to be representation of physically what would happen. It's an idea of what happens if that much flow goes away.

Now, -- or that much flow area goes away. What was observed at CDI was a representation of what presumably would happen and that is qualitative. I mean, I can't -- I'm certainly not going to argue here that a quantitative test was done, I mean, other than the fact that that test measured the pressure drop based on the amount of debris that was in the test.

So, there has been testing of a sort that's been done on it. There has not been analysis of it.

DR. WALLIS: Well, I think the question I would have would be if you had this one foot cube per thousand square feet or some more conservative value and it comes through, where does it go?

The worst it could do is to deposit everywhere uniformly. It's got to go somewhere.

MR. SCOTT: Right.

DR. WALLIS: What do you do then? What do you calculate if that happens? That's the kind of thing I would do. It seems to me more realistic than assuming that it deposits everywhere except in one channel.

MR. SCOTT: I agree, without question, and I don't think that this -- that the computer analysis was done to try to -- again to try to assert that the way it's going to happen is, is 99.4 percent are going to be fully blocked and the other one's going to be completely open. That just -- I don't think that was the intent.

The intent was to show you can get an awful lot of blockage and still show --

DR. WALLIS: Yes, that's very impressive.

MR. SCOTT: -- cooling.

DR. WALLIS: That is impressive, yes.

MR. SCOTT: And the other part of the puzzle, if you will, is that when we ran a test or they ran a test and they did observe a significant blanket of debris below the divider, because of the low flow rates involved and the fact that that debris is fighting gravity, you really -- we didn't see a compressed bed and we didn't see excessive head loss.

DR. WALLIS: No. The part that's missing for me is if all this material that could get bypassed is bypassed, where does it go and what does it do? That's the answers I'm looking for. I haven't really heard it.

MR. SCOTT: Most of it either accumulates in the lower part of the vessel, and this is again based on the observations of the test, --

DR. WALLIS: Out in the lower plenum? Is that the idea?

MR. SCOTT: Much of it settles out there, and much of it ends up in a very fluffy bed at the bottom divider and then some, a small amount, gets through into the core and some of it hangs up in the grid straps and others keeps going and comes out and goes around again and where it probably gets caught by the strainer section.

DR. WALLIS: And the reason it can't make a thin bed is because the flow rate is so low or something?

MR. SCOTT: I would not assert that you can't make a thin bed but what we observed was that one did not occur apparently, based on the appearance of the debris that was there and the fact that we didn't see a very high head loss.

MR. DINGLER: And that was both with the high-particulate/low-fiber which is more likely to have a thin bed than the high-fiber/low-particulate, also.

MR. SCOTT: But let's be clear. This was not an exhaustive multitest program. It was not. I don't want to oversell it.

I'd like to also address a couple of the other questions. Steve Smith, would you come forward, please? Would somebody make a place for Steve at the front?

This is Steve Smith of the NRR staff. HE is one of our sumpologists and Steve is here to answer your questions this morning about bypass and rather than have me attempt to restate them, perhaps you would restate them.

CHAIRMAN BANERJEE: What does your current experience with the prototype tests show in terms of bypass?

MR. SMITH: We have -- I only could find

one that actually had a number associated with it from the audits we've done because the other audits, either we discarded that information after the audit's complete or we -- they didn't have a number associated, but the one that we have was 1.3 cubic feet per thousand square foot of strainer area.

It was done, I would say, quite conservatively. There was no particulate in the water when they did the bypass testing and they did it at various flow rates and they picked the most conservative amount of fiber that was bypassed.

MR. SCOTT: And they ran, you said, about four-five tests?

MR. SMITH: They ran four, four separate tests.

CHAIRMAN BANERJEE: Can you describe these tests a little bit?

MR. SMITH: What they do is they put a prototypical flow rate through the strainer based on either the strainers can either have maybe one or two pumps taking suction through the strainer and they did the flow rates based on one and two pumps. It ended up that the higher flow rates generally end up with higher bypass because you get more DP across the strainer, so that kind of makes sense.

So, they set up the flow and then they put the -- they slowly introduce the fiber into the flume and the fiber builds up on the bed and they take samples periodically. Like they start out more frequently, say every minute and then every three minutes, every five minutes, and they determine what the bypass is at each period of time and then they total it up, and the bypass does decrease dramatically as time goes on.

CHAIRMAN BANERJEE: And is this -- what is these typical velocities through the screens?

MR. SMITH: The typical velocities are generally less than .1. The approach velocities are less than .01. A lot of the screen actual -- because of the --

CHAIRMAN BANERJEE: Less than .01? Less than a second?

MR. SMITH: Less than .01 feet per second actually passing through the screen, yes.

CHAIRMAN BANERJEE: And is this supposed to present some physical situation downstream? Is the flow turbulent?

MR. SMITH: The flow through the bed is generally laminar.

CHAIRMAN BANERJEE: No, but the upstream

flow?

MR. SMITH: The upstream flow is probably turbulent, yes.

CHAIRMAN BANERJEE: But if it's .01 feet per second --

MR. SMITH: That's -- well, that's actually as it's hitting the strainer. Okay? It's coming in -- that's a screen approach velocity. If you took the whole thing as a complex shape and flattened it out, it --

CHAIRMAN BANERJEE: So, the shape is -- is it a flume leading to the strainer or is it a parallel flow and the strainer is on the side? How is it set up?

MR. SMITH: There's several different types. I don't know. I wish I had pictures. Some are pockets that are deep pockets and the flow goes into the pocket and then approaches from there. Some are -- most of them are just flat plates that are attached to a central plenum and the flow -- it flows towards the strainer and then as it goes between the plates, it slows down as it approaches the strainer. So that's why it's so close.

MR. SCOTT: To answer your question slightly differently, the flows that can approach the strainer are going to vary significantly with the strainer design and the strainer installation in a given plant.

Whatever that situation may be for a plant, staff expects the licensee will model it in their test plume. So, in other words, if there are nearby obstacles to flow that would cause the flow to be diverted or otherwise changed in the vicinity of the strainer, the staff expects that to be modeled at the test with some kind of a plate or something.

So, if your question is about testing, it's one thing. If it's about what's in the plant, that's something else.

CHAIRMAN BANERJEE: No. What I am really interested in knowing is whether this fiber material is in suspension or is it settling out before or much of it is settling out before.

MR. SCOTT: If the licensee seeks to credit settling before the strainer, they need to show us that that settling is prototypical and would happen in the real plant and sometimes that can be a challenge for them. Otherwise, we expect them to make sure that the appropriate debris gets through the strainer. It does not settle out.

CHAIRMAN BANERJEE: Is there settling or

not?

MR. SCOTT: Say again.

CHAIRMAN BANERJEE: In this case that you're talking about?

MR. SMITH: In this case, there was not settling. There was turbulence. There was significant turbulence upstream of the strainer that kept the fibrous debris suspended.

DR. WALLIS: When we had a presentation from one of these testers, the explanation of the very small bypass was that the fibers had a little short shot of bypass and then the fibers covered the screen and the fibers prevented any more bypass. So, I think you have to worry about is a situation where you don't cover the screen with fibers and you still got small fibers available to go through.

MR. SMITH: If you don't cover the screen with fibers, that indicates you don't have much fiber.

DR. WALLIS: Well, it depends on how you put them in, the order in which they arrive and all sorts of things.

CHAIRMAN BANERJEE: Not at all, because if you have these screens which are laid across around the circumference of the containment on the outside, --

MR. SMITH: Yes.

CHAIRMAN BANERJEE: -- the flow comes in at one side and it starts to draw flow as you go along, so that you'd expect the screens would start to block from closer to the entrance and as you go further down, it's progressively blocked. So, it would take quite a long time for it to block. I can draw it for you.

MR. SMITH: We're familiar with that. I agree. I agree with that.

CHAIRMAN BANERJEE: So, I think you can get a lot of stuff through.

MR. SCOTT: Okay. Again, the point is, is that, you don't run -- correct me if I'm wrong here, Steve. You don't run one head loss test and take your downstream bypass from that test because, as you've all pointed out this morning, you're trying to accomplish a different thing in that head loss test versus the bypass test.

In the head loss test, you want to maximize the blockage at the strainer. In the bypass test, you want to minimize the blockage at the strainer to be conservative. So, it's not one test, one size, one objective fits all and the staff's expectation of the licensees is that they show that they have again prototypically or conservatively determined what the bypass is and so as you heard Steve say, a number of them are sending fiber only for the bypass tests, so the particulate doesn't hang it up on the strainer and prevent it from going downstream.

CHAIRMAN BANERJEE: Well, what I've heard Steve say is that you don't have numbers for the bypass for most of the tests that have been done. You've only got numbers for one test.

MR. SMITH: Well, one of the plants did not even do bypass testing. They made some assumptions that a lot of fiber bypassed the strainer. It was an incredibly high amount, and I believe that they may have to go back, based on some of the downstream, and actually determine what their bypass would be, but some plants have not even done testing. They've just assumed -- there's a WCAP-16406 that gives you some guidance for assuming and calculating bypass and that comes out very conservative compared to what the testing's showing us.

MR. SCOTT: We are not to the point, having just started the reviews of the licensee submittals, to make a call on how good a job they've done on that. All I'm telling you is what our expectation is and what we've observed in a couple of tests and we visited several tests and observed that that's what they were doing, was sending the fiber.

CHAIRMAN BANERJEE: It would be a good idea to keep this data.

MEMBER ABDEL-KHALIK: I guess one concern I have is that in the final analysis, what is being collected and reported is one integral number, certain whether it's 1 or 1.3 cubic feet per thousand square foot area, and yet there are significant transient effects in this process, as you indicated.

The bypass fraction decreases very rapidly, depending on, you know, how quickly you form a bed on the strainer that blocks any further fibers from going through and I haven't seen, you know, any, you know, systematic evaluation of these transient effects.

MR. SCOTT: And that is not being done on a generic basis. The licensees are being expected to use their plant-specific debris mix to do this kind of test. So, there is no generic test of that sort. The licensees have to figure their own bypass.

CHAIRMAN BANERJEE: So, if the licensee estimates that 10 cubic feet per thousand square foot get through, I mean I can probably think of ways it could happen, how --

MR. SCOTT: Okay.

CHAIRMAN BANERJEE: -- do they do this?

MR. SCOTT: Well, they would be in a situation, if the topical report -- the topical report has certain assumptions that if they stay within -- I shouldn't say assumptions, parameters. If they stay within those parameters, then they can rely on the topical report and if a licensee calculates a higher bypass and doesn't meet those parameters, then they have to run an analysis or a test themselves.

CHAIRMAN BANERJEE: But the topical gives no methodology, as Graham was pointing out, to handle that.

MR. SCOTT: Now, as I recall, the topical -- have Ralph Landry help me out here. There was something about bounding Delta P, that if they stayed within that, they were okay. I don't recall the exact context. Do you know what I'm talking about?

DR. LANDRY: I don't remember the exact statement right off.

MR. SCOTT: There is a boundary condition that if they stay within it, then it indicates that -- and you and I went back and forth on this. It indicates that they are bounded by that topical report, Delta P.

If you don't remember it, I'll have to dig it out of the text. There is a criterion in there, and I don't recall it off the cuff, and if they stay within that criterion, the staff believes that they are adequately covered.

CHAIRMAN BANERJEE: Okay. So, I think with regard to the bypass, we've heard from Steve, and is there anything else?

MR. SCOTT: You had a question on -- was it fiber size distribution?

CHAIRMAN BANERJEE: Right.

MR. SCOTT: Wasn't it? What was the exact question? If you could ask it again?

CHAIRMAN BANERJEE: If you had any measurements of the fiber size distribution at generation and apparently there's some old reports that Ralph referred to where these experiments and things have been done, but that's a more generic question. It doesn't have to do with this meeting specifically.

MR. SCOTT: Okay. Well, do you want to just --

CHAIRMAN BANERJEE: Yes, I think we can table that.

MR. SCOTT: Okay.

CHAIRMAN BANERJEE: There's a lot of interest in the size distribution of particles and fibers.

MR. SCOTT: And we have some information on that.

CHAIRMAN BANERJEE: I don't think that needs to be answered here.

MR. SCOTT: Okay. Fair enough. So, I guess we're ready for Ralph and Paul then.

CHAIRMAN BANERJEE: All right.

MR. KRESS: How do you measure the size of fiber? I mean, it's a long, thin thing. What's the -- when you give it a size --

MR. SCOTT: We take a nuclear grade ruler and --

MR. KRESS: That's what I figured.

MR. DINGLER: I can speak for what Wolf Creek's doing. We're actually taking a ruler and we're putting them under a microscope and measuring them.

MR. KRESS: Measuring the length?

MR. DINGLER: Yes.

MR. KRESS: That's called the size?

MR. DINGLER: Length, yes.

MR. KRESS: Okay. I just wondered.

MR. DINGLER: That's why it's -- each bottle is about a day's worth of work to do and it's not cheap.

MR. KRESS: Not much fun either.

MR. DINGLER: No, not much fun either.

CHAIRMAN BANERJEE: And you can't get this from scattering experiments, the idea of the distribution?

MR. DINGLER: What we did -- I'll speak for what we did, not generically here. What we did at Wolf Creek is we went in and we took samples based on a time basis and we've got -- for each test, we've probably got 70 bottles of liquid for each test. We'll look at those bottles and we'll look at the timing and then we'll take right now it looks like about 40 bottles we're going to test to do a curve.

CHAIRMAN BANERJEE: Okay.

MR. DINGLER: And each bottle, we're going to measure the length and the amounts in those bottles.

CHAIRMAN BANERJEE: Okay. So, who's going to lead off? Ralph or --

MR. SCOTT: Yes, Ralph will lead off. I asked him to give you copies. Okay. We're ready to go.

CHAIRMAN BANERJEE: Go ahead.

NRC Staff Presentation on Draft SE

DR. LANDRY: Okay. I feel like I presented a great deal of this material already.

MR. SCOTT: Ralph, before you start, you want to introduce your colleagues there to your left.

DR. LANDRY: I was getting to that. Mike is determined he's going to get the last word in.

MR. SCOTT: That never happens.

DR. LANDRY: We have discussed a great deal of the material already today, but what I would like to do is go through the staff's review of the WCAP and the results of our safety evaluation report.

Joining me today are Paul Klein, who we've heard from a great deal already, he performed much of the chemical analysis in the topical, and Bob Litman, consultant to the staff, who assisted in performing the chemical analysis.

This was the intended outline for today. We've covered a lot of these topics, so I'll try to hit a number of them fairly quickly and get down again to, I think, the stuff that's most interesting to the committee, talk a little bit about the core inlet blockage analyses that we did and the local heating of the fuel rods and then try to turn it over to Paul and Bob to talk about the chemistry and come back and look at the conditions and limitations which are an area that I think that you're pretty interested in this afternoon.

This is the approach to the review of the WCAP. Let me --

DR. WALLIS: Are you aware that there's any model for deposition of solids in the WCAP, your Item 2?

DR. LANDRY: For deposition of solids, you know, the --

DR. WALLIS: You're saying industry models for deposition of solids. I'm not aware that there is. There's a deposition of scale or something like that. Is that what you mean? It's not -- by solids, you don't mean fibers, do you?

DR. LANDRY: I think we mean particulate here. The LOCADM does include deposition of any particulate that's carried to the fuel clad.

DR. WALLIS: I think it could build up on the clad that they talked about, the layers, the uniform layers, but that's -- okay. Sorry. There's nothing in the WCAP about where the fibers go and how they build up and how you calculate it?

DR. LANDRY: No.

DR. WALLIS: Thank you.

DR. LANDRY: The WCAP is based on the limit on the maximum temperature of fuel clad. It's established based on conservative value that prevents fuel damage which we've already discussed at great length today.

The industry-recognized models for deposition of solids and the calculation of temperature increases based on heat transfer coefficients are used. Flow simulation code, W/COBRA TRAC, is used to assess limit on flow reduction. We talked about that quite a bit.

The results of the WCAP-16530, total material dissolution, are available to be deposited on the core surfaces. Size and quantity of fibrous material entering the lower core region is estimated from the containment sump screen dimensions and plant fiber bypass test. Deposition of the material on the lower core plate leading to flow blockage is assessed and particulate and fibrous material matter that passes through the lower core plate is evaluated for flow blockage and deposition effects.

The thickness of the deposits, the oxide plus crud plus chemical deposit, are formed or calculated using the LOCADM as we discussed --

DR. WALLIS: When you use words like "assessed" and "evaluated," that gets back to my previous statement, it seemed to me that this was a very qualitative assessment. They were saying it was so small, they wouldn't stick and things like that. They're so small that they won't bridge the gap between or something.

They weren't methods for calculating what happens.

DR. LANDRY: There are assumptions made -- there are -- there's the one CDI test which we looked at --

DR. WALLIS: Yes.

DR. LANDRY: -- and which I'll have some comments on, and then there are assumptions made in performing code calculations, and from those we draw conclusions as to the amount of margin that's available.

Some brief words on the application of the WCAP by the licensees and again we come back to this at the end of the discussion, but we really wanted to get some of these comments out right at the front so you had an idea of where we were going.

Licensees are likely to take credit for

the WCAP as bounding for their plants and showing that in-vessel downstream effects will not cause unacceptable impacts on the fuel. Application of the WCAP is to be in accordance with conditions and limitations contained in the staff's safety evaluation report.

Licensees are expected to verify that the assumptions in the WCAP methods are conservative with respect to their individual plants. However, we also expect that there will be licensees who choose to develop or substitute plant-specific data and in particular such data as the chemical species that are contained in their plant which are not the same as the species assumed in the WCAP.

Each plant is going to be a little different and we expect that each licensee will use the plant-specific species rather than the assumed species of the WCAP.

DR. WALLIS: I don't see how your evaluation can only be plant-specific. I said this earlier today. I mean, if 50 plants come in saying they get one cubic foot per thousand square foot and two plants come in and say we did tests and we got 20 foot cubic per thousand square feet, you can't ignore that information when you look back at the other plants, can you?

MR. SCOTT: These sorts of parameters are going to vary significantly, potentially, from plant to plant. We could, if it made sense to do so, undertake to try to sort all that out and I can't tell you sitting here today whether we are prepared to do that or not.

DR. WALLIS: It may well indicate that the tests were slightly different rather than the plants are different.

MR. SCOTT: It could, but the plants do vary significantly. I mean, one of the things that we have been trying to do with the head loss testing of the strainers is to indeed sort out all these variations that we see from vendor to vendor. The argument you will hear today is that we don't at this point believe that necessary for this particular situation. You may have a different conclusion.

MR. KLEIN: I think, in general, the way that this is being worked by the staff, though, when there's a surprise in a given area, a great deal of effort and communication goes into trying to understand that surprise and understand if it's unique to a given licensee or applicable across a fleet.

MR. SCOTT: That's absolutely right and to build along what Paul said, we only have a limited number of individuals who are going to be doing the reviews of these packages, generally only one or two people. So, if something sticks out like a sore thumb, I have every confidence that the staff doing that review will bring that up.

Now, because we are doing these reviews holistically and we're considering whether, based on inputs from all these many areas, the plant has shown compliance, the fact that there is an anomaly, say, in a particular area may or may not occasion the need to go around again with that plant or to evaluate something on a more generic basis.

I can't predict that, but we're certainly not insensitive to unexplainable or unexplained anomalies. So, I think we're aware of that.

DR. LANDRY: I am not going to spend a lot of time on the regulatory evaluation. I think we've been through a lot of this and everybody's aware that 50.46, Section B, Paragraph 5, is the applicable section to this discussion.

Mike already discussed the Generic Letter that was sent out in 2004. We sent a clarification to Westinghouse which was then carried forth to the PWR owners' group in 2006. That clarification was saying that the coding capability had to be demonstrated despite challenges from chemical or physical effects and that the mission time is to be demonstrated when the bulk and local temperatures are shown to be stable or continuously decreasing.

Let's look again at the blockage at core inlet. We've talked about this quite a bit today. We spent many hours on it, but I'd like to break it down into two parts: looking at the analytic part first and then talk about the experimental part which the owners' group provided.

Core inlet blockage calculations, as you've already heard, have been conducted by the owners' group using COBRA TRAC and conducted by the staff using RELAP5 and TRACE. I'm going to focus on the TRACE calculations in a minute.

We also performed calculations using the FLUENT CFD code to give us a sanity check on the core flow distributions that we were seeing with TRACE and that the owners' group was seeing with W/COBRA TRAC.

The calculations that were performed, the systems analysis calculations consistently showed that we could sustain a 95 to 99 percent blockage at the core inlet and still have a minimal heating of the core. In the case of the TRACE calculations, that calculated peak temperature increase was only about 10 degrees. Some people want to read it as four degrees. It depends on how you want to read the curve.

Staff analyzed core blockage for Westinghouse 412 Class plant. That's a four-loop 12-foot core class plant. We performed four cases: the unblocked case, a 75 percent block, 87.5 percent block, and a 95 percent block.

DR. WALLIS: You blocked everything?

DR. LANDRY: I can't hear you.

DR. WALLIS: You blocked all the channels except for one or two, the same way that Westinghouse did it?

DR. LANDRY: Ours was similar to theirs, but not identical. When we did the blockage, we did not go and have a specific fuel assembly. We had a slot and that slot would vary out by the percentage of blockage to a segment of the core. The slot began at the center and went to the edge of the core. Then we would move it out.

Seventy-five percent block was three sectors, three quadrants were blocked and one quadrant was not. So, our blockage was not a particular assembly but rather a slot that began at the center and worked its way out to the edge.

CHAIRMAN BANERJEE: Well, looking at their Slide 43, if you blocked it to not 99 percent but 99.6 or 99.7 percent, you probably would get a flow rate lower than that required for the core boil-off and therefore you'd get fuel heat-up.

I mean, it's just a question of whether you're feeding enough water in to take out the decay heat by boiling. So, if you just decrease the inflow by a factor of three, you would get the boil-off exceeding the inflow and you'd be in trouble. That's really the bottom line.

DR. LANDRY: We don't get to that point. Bear with me.

CHAIRMAN BANERJEE: Okay.

DR. LANDRY: This is a plot of the peak cladding temperature that we got for the double-ended cold leg break. When we went out to 1,200 seconds, about the same time that the owners' group induced their switch-over to recirculation and blockage, where the owners' group ramped up the blockage, we imposed an instantaneous blockage. We stopped the calculation, blocked off the area of 75 percent, et. cetera, of the core, and then restarted the calculation.

So, these temperatures are the

temperatures that result following an instantaneous blockage. Now in reality that would not happen. You would have a blockage, if it was going to occur, that would have built up over a period of time following the switch-over to recirculation.

So, in that respect, this is highly conservative because we've instantly blocked a very large segment of the core and if you look at the curves, the red curve is the 95 percent blockage value. Some of the staff want to argue that you should look at the peak of that temperature versus the peak of the unblocked temperature to say what the increase is. I prefer to go from its lowest point to the highest point and there I get a temperature increase on the order of 10 degrees.

You can see that there still is quite a bit of movement around of the temperatures, even for the unblocked case. So, these temperatures are not constant temperatures, but they are a declining temperature over the period of time.

When we look at --

CHAIRMAN BANERJEE: How full is the core when that recirc pump is turned off or turned on or whatever?

DR. LANDRY: Okay. That brings me to the

next slide.

CHAIRMAN BANERJEE: Okay.

DR. LANDRY: The next slide shows the collapsed liquid level in the core. The entire core has been quenched, so that there is a two-phased mix all the way to the top of the core.

We see in this slide that beginning at 1,200 seconds, when we've gone into the recirculation mode, even though we've looked at four different cases of blockage, the collapsed liquid level is essentially the same for all four cases. It makes very little difference whether we're blocked or at 95 percent or totally unblocked. We still see that the collapsed liquid level is above the midplane of the core and it's moving in much the same direction. It looks like there's a wave motion there for the liquid level, but all of the temperatures for all -- or all the liquid levels for all the blockage cases are following the same pattern throughout the core.

When we look at a region immediately above the blockage area, we see voids forming immediately above the blockage and for two of the cases, 87.5 percent and 95 percent, we see that there's a moderate amount of voiding occurring immediately above the blocked area.

The other area, the 75 percent, the red line, you don't see until further out in time and just a very slight little movement in that figure.

But what happens as we move up the core, when we get to the top, we see that there's very little change in the void fraction at the top of the core, the material exiting the core, which led us to believe right away that there was a lot of cross flow being calculated.

The TRAC -- the TRACE -- excuse me. Going back too many years. The TRACE model was set up to use two radial rings for the core, eight azimuthal sectors and 14 axial nodes. So, this gave us a fairly fine mesh but not real fine division of the cores that we could get radial flows, we could calculate azimuthal flows, we could have axial flows.

Now, as I said earlier, we were concerned about were these flows reasonable and --

CHAIRMAN BANERJEE: Before you go on, Ralph, this 95 percent blockage, what sort of -- if you took the head available and looked at the flow, what sort of pressure losses were you getting across the debris bed? Is it a few psi or is it --

DR. LANDRY: This was assuming total blockage of the blocked area. There was no pressure drop across the area that was blocked.

CHAIRMAN BANERJEE: I'm saying equivalent pressure drop.

DR. LANDRY: What we did was we reduced the flow area.

CHAIRMAN BANERJEE: Right.

DR. LANDRY: We did not induce a head loss like the owners' group did with their calculation. This was a total loss of flow across that blocked area.

CHAIRMAN BANERJEE: I understand, but what I'm really asking you is that's the equivalent to saying that if I -- what I'm trying to back out from this is if I spread this debris uniformly, what would that be equivalent to in terms of pressure loss? Because when you have only -- given a certain pressure head, when you have 5 percent only of the flow going through, that means you have a sudden pressure drop. You can look at it that way.

So, I'm trying to figure out what would be the pressure drop across a screen --

DR. LANDRY: What would be an equivalent pressure drop?

CHAIRMAN BANERJEE: Equivalent pressure drop.

DR. LANDRY: We did not go back and try to estimate that.

CHAIRMAN BANERJEE: Because that is sort of to me, it seems important issue because we know roughly what pressure drops we're getting across screens for different debris thicknesses. It depends on the order and all that sort of stuff but we weren't ideal anyway, and is this in the ballpark or is it much higher or is it much lower?

DR. LANDRY: I think we'd have to go back and --

CHAIRMAN BANERJEE: Take a look at it.

DR. LANDRY: -- try to do an estimation of what an equivalent pressure drop for the total area would be.

CHAIRMAN BANERJEE: That might actually answer my question.

DR. LANDRY: Yes, as I said earlier with Said's question, that the flow across the boundary of the unblocked area with the highest blockage was only on the order of a quarter of a meter per second. So, we aren't getting extremely high flows. We're not having sonic flows or anything of that nature, but these are reasonable flows.

So, we would have to go back and re-estimate what kind of equivalent pressure drop you could have. Now, we did --

CHAIRMAN BANERJEE: That's important to me, I'll tell you why, because I don't know whether 95 percent or 87 percent or 50 percent is a reasonable number or 99.7 percent is a reasonable number. I do know if you block, looking at the graph, if you block 99.7 percent of the channels, you'll get too low. It will boil off faster than you can get water in.

DR. LANDRY: Okay. But let me -- bear with me for a minute, Sanjoy, and let me get to --

CHAIRMAN BANERJEE: Okay.

DR. LANDRY: -- another point as we go through the rest of this.

We on the staff decided that we needed a sanity check, as I said earlier, on the flows that would occur within the core. Were these radial flows, azimuthal flows reasonable that could produce these kinds of cooling effects?

So, we modeled half of the core with 400,000 cell model, which we used the TRACE inlet conditions as the boundary conditions to start the flow into FLUENT, and we ran 75 percent, 87.5 percent and 95 percent blockage in the FLUENT model to see what kind of flows would we get.

We found that when we ran those flows through FLUENT, we got a radial flow that spread very rapidly throughout the core, so that even though FLUENT is single-phase, we're not getting the phase change that we were getting with TRACE, but we do get the density changes and we do account for heat transfer.

With FLUENT, we are getting the same kind of flow patterns that are within reason, they're not violating any viscous laws or conditions for FLUENT.

CHAIRMAN BANERJEE: Did you run it with a free surface at the top?

DR. LANDRY: Yes.

CHAIRMAN BANERJEE: So, if you're getting any level changes, it was just spreading out?

DR. LANDRY: Right, right. So, we're getting flow patterns that are reasonable and consistent with the kind of flow patterns -- they're not identical to the TRACE, but they are within ballpark of the TRACE flow patterns.

So, we concluded that the calculation that we're seeing with the systems code was giving us a reasonable estimate of what would be happening in the core with a large degree of blockage.

Now, when we look at the experimental

work, you heard from the owners' group earlier that when they performed some tests on the strainer, systematic continuum dynamics, CDI, they added on to that test this mock-up bundle of a core and they showed how much the fibers were captured at the lower fuel nozzle, the guardian grid that was supplied by Calvert Cliffs.

This picture that I passed around earlier was the lower inlet nozzle. This is an actual nozzle from Calvert Cliffs. So, this is prototypical.

In the test, they found that the fiber did not accumulate sufficiently within the assembly to cause internal blockage. The fibrous material from the screens was from the screen strainer bypass and I passed around a vial earlier that showed you the kind of water and debris that would come through a screen.

Now, the staff, however, does not consider these tests to be highly typical because of the prototypicalities of the fuel assembly mock-up that were being used and the way that the materials were being introduced, but the tests do provide good qualitative information.

As you heard earlier, the fuel assembly simulator was only a foot and a half long. It was made out of plastic rods instead of metallic rods.

They were unheated. They'd only had two spacer grids, so it did not provide anywhere near the kind of pressure drop that you would see from a prototypical mock-up.

DR. WALLIS: Ralph, did you look at this German experiment that we referred to earlier?

DR. LANDRY: We do not have that information.

DR. WALLIS: Because we actually saw the experiment and it didn't look quite like what you showed us in your tests in terms of where the fibers went.

DR. LANDRY: I have not seen that.

DR. WALLIS: But I think that Mike said that you had just got access to it or something?

MR. SCOTT: We got access to some materials that Dr. Banerjee had sent to us from the meeting. I don't know for sure whether that particular --

DR. WALLIS: I think we recommended that you go after the original source when we got back and I wondered if you'd managed to do that.

CHAIRMAN BANERJEE: Well, we got a letter about that, that they want something in exchange. I'll forward the letter to you.

MR. SCOTT: Right. And the last thing I knew, that was still under discussion, right? We don't have it.

CHAIRMAN BANERJEE: We don't have the reports. I mean, all you have is whatever I sent you.

MR. SCOTT: Right.

DR. WALLIS: All you have is this unreliable observer.

MR. SCOTT: Slide shows, I believe, right, from the quadripartite.

CHAIRMAN BANERJEE: They didn't send you the written documents from the staff?

MR. SCOTT: No, not that I'm aware of. I have a porous in-box that frequently hides things from me. It's entirely computer --

DR. WALLIS: It gets blocked?

MR. SCOTT: Well, it just disappears. It's phantom e-mails. So, I won't swear that nobody sent me something, but I'm not aware of it.

CHAIRMAN BANERJEE: I'll check whether it was sent to you.

MR. SCOTT: Okay. Thank you.

DR. LANDRY: Okay. As we talked about earlier today, the measured pressure drop in this test was only a third of a psi across the blockage material and while the staff does not accept the CDI demonstration as a rigorous test, we do agree with the conclusions that adequate core flow would not be inhibited and this is getting back at your question, Sanjoy, that based on all this material put together, when we look at the amount of material that was carried through and did not appreciably block up the inlet in this CDI test and if you remember those pictures of the bucket of material, the calibrated bucket that was used to pour in the material, the way that lower plenum in the test facility looked, and then you compare it with the water that came through an actual strainer test, you get the feeling that --

DR. WALLIS: Excuse me. I don't understand how you can say that you don't accept the test but you agree with the conclusions.

DR. LANDRY: We agree with the qualitative conclusion that the amount of material that was injected is not going to appreciably block up the inlet to the fuel assembly.

Now, when you take that and you compare it with the analyses that were done, the analyses show that you can withstand a 95 percent blockage and still not heat up the fuel appreciably.

DR. WALLIS: That's another matter,

though, than the first bullet.

DR. LANDRY: Well, we're taking all of this material together. We're not focusing on any one point. When we look at what the calculation tells us we can --

DR. WALLIS: Excuse me. Then, so the second part of the first bullet really is the deduction from the second bullet? Is that what it is? What is the basis of the second -- of the conclusion under the first bullet?

DR. LANDRY: That when you pour a large quantity of material into the inlet of a fuel assembly, you will not block the fuel assembly to the point that you cannot get --

DR. WALLIS: How do you know that?

DR. LANDRY: -- flow through it. From the tests that they ran.

DR. WALLIS: From the CDI tests?

DR. LANDRY: The CDI tests did not block up the assembly inlet.

DR. WALLIS: So, you're accepting the results of that tests then?

DR. LANDRY: We're not accepting any data from the tests. We're accepting the qualitative --

DR. WALLIS: How can you accept the

results if you don't accept the data?

MR. SCOTT: I think the way -- let me try it. We are evaluating this and the other aspects of GSI-191 holistically. This test, all the information we had, we would say was not enough to stand up. Holistically, when we evaluate this test in conjunction with the analysis results, we conclude that there is --

DR. WALLIS: Which analysis results are these?

MR. SCOTT: The various ones that he -- that Ralph has been discussing.

So, the combination of that information --

DR. WALLIS: The analysis of deposition on the --

DR. LANDRY: No, we did analysis of blockage and the effect of blockage.

DR. WALLIS: That's the second bullet, that's the second bullet.

DR. LANDRY: When we look at the analysis that we performed, we look at the analysis that the owners' group performed, when we look at the material that we measured or that we collected coming through a strainer and we look at the amount of debris that they poured into the lower plenum of a "test," if we want to do it that way even, we come away and we say we don't see a basis for saying there is no way that this core can be kept from --

DR. WALLIS: So, if I come along and say that Argonne did the same tests with the same fibers and the same particles but with a different screen and the same -- they got an enormous resistance, what's different?

CHAIRMAN BANERJEE: They had chemicals.

DR. WALLIS: They had chemicals, too. That's right. You didn't have chemicals?

CHAIRMAN BANERJEE: Yes, there are two aspects to this. Maybe I'm trying to understand what Ralph is saying.

So, if you take, let's say, the amount you're letting through the strainers which is, say, five cubic feet for 5,000 square foot strainer, if you now spread it just over the holes at the core inlet, it gives you something like .1 feet thick, if it was uniformly there, which is about -- what is .1 feet? About one inch, okay, in these interstitial spaces.

That this one inch of fiber with maybe some particles and chemicals would not block the flow. That's really what I understand you to say. Even if the sort of TRACE run that you've done is this thin bed blows through in certain regions, so you've got little blow-through holes, and what you're -- physically, the argument to me seems to be that with one inch of this mat or whatever is on there, that you will get blow-through holes. That's sort of the way I'm looking at this.

I'm trying to picture it physically, you know, how this could happen that you could get enough cooling, that you'll get some blow-through holes of above 5 percent of the area or something like that.

DR. LANDRY: And that would be enough, that would still be enough to maintain core cooling.

CHAIRMAN BANERJEE: Yes, 5 percent. The question is if you don't get these blow-through holes and it's really a mat, would you get enough flow?

DR. LANDRY: If you have a 100 percent blockage --

CHAIRMAN BANERJEE: Well, it lets some things through, but it won't let 5 percent through.

DR. LANDRY: Right.

CHAIRMAN BANERJEE: Right.

DR. LANDRY: Now, also keep in mind, when we did our calculations, the staff calculations, we did not allow any of the baffle flow areas which we discussed --

CHAIRMAN BANERJEE: Right.

DR. LANDRY: -- earlier. There's a lot of holes around the core barrel, around the baffle. WE did not allow any of those to have flow. We sealed all those holes all the way around. So, this was -- when we said core blockage, this was only the inlet at the bottom of the core. There was no other flow coming in.

CHAIRMAN BANERJEE: All concepts have been baffles and holes and where are they located?

DR. LANDRY: They're at various levels up the assembly.

CHAIRMAN BANERJEE: Where is the lowest ones?

DR. LANDRY: I'm not sure where the lowest one is. I know that they go from the top to the midplane, at least to the midplane, and many of them are slot-shaped, so they're not just holes, they're slots, so that those are distributed around the core baffle and up the core baffle.

When we did our analysis --

CHAIRMAN BANERJEE: And there is a box around that doesn't go through the inlet or anything?

DR. LANDRY: Right.

CHAIRMAN BANERJEE: That's --

DR. LANDRY: This is the baffle region that allows for bypass.

MR. ANDREYCHEK: Well, if I may for a moment, the -- you're talking about the flow pass-up through the baffle barrel region. The inlet to those is at the bottom of the fuel and below the core plate and the flow is up through there.

The first baffle barrel for some of the Westinghouse designs is about approximately two feet up and then there's another one another two or three feet up and another two or three feet above there and it provides the pressure relief during the LOCA and it also provides cooling for the baffle barrel region during normal operation.

The B&W design has something approximately similar. The B&W design for the proposal in the baffle barrel are approximately similar. Instead of my two-inch diameter holes -- say again. How high up are they?

CHAIRMAN BANERJEE: You have to speak into the mike and identify yourself.

MR. WISSINGER: Gordon Wissinger, AREVA. I'm sorry. What was the question?

MR. ANDREYCHEK: The baffle barrel holes.

CHAIRMAN BANERJEE: Speak into the mike,

please. Otherwise --

MR. ANDREYCHEK: The baffle barrel holes for the B&W design are approximately two inches in diameter, give or take a little?

MR. WISSINGER: Yes, they're actually about three-quarters.

MR. ANDREYCHEK: Okay.

MR. WISSINGER: We probably have more than you have.

MR. ANDREYCHEK: And they are spaced like two foot, so on and so forth.

MR. WISSINGER: They start about 40 percent of the way up. So, we've got your baffle plates and then former plates. There's four or five levels of those going up. They are up above the first former plate, about 40 percent of the way up the core, and then they go the rest of the way up. There's a row in between all the different formers.

CHAIRMAN BANERJEE: And the entrance to this region from the lower plenum, is there any debris catches there or anything?

MR. WISSINGER: No, those holes down there tend to be -- the smallest hole there is about an inch and they tend to go up to three-four inches, depending on where you are on that plate. So, the lower core plate around that periphery is fairly wide open into the baffle region.

CHAIRMAN BANERJEE: So, the flow could go through that baffle region?

MR. WISSINGER: Absolutely. And the holes in the former plates, which are the horizontal plates, are also fairly significant, like an inch to an inch and a half in general.

CHAIRMAN BANERJEE: And, of course, the flow is then eventually let through the core and out, right?

MR. WISSINGER: Yes, during normal operation, basically it will go up from the bottom and then either divert into the core or it will continue all the way to the top and rejoin the flow in the upper plenum. So, during a refueling-type situation, you would fill that from the bottom and then it would flow into the core and eventually when your two-phased mixture gets to the top of the core, it's going to go all the way up into the upper plenum as well.

Depending on the flow patterns, it may actually go up in the core and circulate back down through the baffle and that sort of thing, if that makes sense.

CHAIRMAN BANERJEE: So, it's open at the

top?

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: I remember analyzing the LOFT results. We had a lot of trouble with all of this.

DR. LANDRY: Right.

DR. WALLIS: Ralph, could you go back a slide, please? This second statement, this is based on the CDI test?

DR. LANDRY: Right.

DR. WALLIS: Second statement here, as part of that table that Tim showed us?

DR. LANDRY: Right.

DR. WALLIS: Now, at Argonne, when they added chemicals in some tests, it was worth about a factor of a 100 in pressure drop.

MR. KLEIN: Yes, I'd like to address that.

DR. WALLIS: So, if you were to add chemicals to this, it's conceivable, even though if you accepted the CDI test, you might have a much bigger pressure drop.

MR. KLEIN: The data that you haven't seen, Dr. Wallis, from the particular licensee that did the CDI-type test and then they added the WCAP surrogate to the test, they do in fact have a higher head loss and just to give you some details of that test, this particular licensee had run four different bypass tests with different debris addition sequences, et. cetera, and then they picked the bounding bypass amount to add to the test that included chemicals.

So, adding that as the base and then adding a 100 percent of WCAP surrogate, which we believe is a very conservative test, particularly at elevated temperature, the final head loss values ranged from about five inches of water up to a maximum of 70 inches of water.

DR. WALLIS: A test just like the CDI test?

MR. KLEIN: Yes, it's a CDI test with chemicals.

DR. WALLIS: Okay.

MR. KLEIN: They varied the chemical debris as well. The highest head loss had more than twice as much WCAP surrogate as the other lower pressure drop had.

DR. WALLIS: So, the WCAP didn't have as much effect as in some other tests?

MR. KLEIN: It had less effect than it has had in the vertical head loss loop at Argonne.

DR. WALLIS: All right.

CHAIRMAN BANERJEE: But in the horizontal screen tests, do you see a smaller effect of the WCAP surrogate?

MR. KLEIN: In general, yes, we do. In the larger-scale industry integrated head loss tests, we see much less dramatic head loss, although, you know, it's hard to give you a value because it is very plant-specific and debris-bed-specific.

CHAIRMAN BANERJEE: When you say 70 inches of water, what fraction of the available pressure head is that?

MR. KLEIN: I don't have that information in front of me.

CHAIRMAN BANERJEE: Well, what is the available pressure?

MR. ANDREYCHEK: If I may address that question? I believe that that head loss was associated with the flow rate associated with a hot leg break. So, you were running -- they were running a lot more flow through that bed at that time and what you were seeing was a head loss associated not only with the collection of material but also with the higher flow rate through that bed which was representative of a hot leg break or maximizing the flow through the bed.

At lower flow rates associated with making up boil-off for cold leg break, they saw much lower head losses, if I remember correctly, Paul.

MR. KLEIN: Yes. I can't speak to that, Tim, because the details weren't in this particular section that I recently reviewed.

I would add, though, that the amount of sodium aluminum silicate and aluminum oxyhydroxide that was added to the test, we would not expect nearly that much in a realistic situation and in fact, at the higher temperatures, we'd expect that material to go back into solution. So, we think this is a very conservative test with respect to the chemical addition.

CHAIRMAN BANERJEE: What was the -- you don't know the approach velocity on that?

MR. KLEIN: No, I don't have those details in front of me.

CHAIRMAN BANERJEE: Because typically what we're looking for are numbers for approach velocities around .1 feet per second. If you've got about .1 feet per second in the core, then you've got enough coming in to boil off. I think our rough numbers show that you have to have about three centimeters per second but that's a rough calculation, if you evenly distributed that.

So, it would be interesting to know what the approach velocity was. Was it .1 feet per second or was it lower or higher?

Anyway, let's carry on.

DR. LANDRY: Okay. The boric acid precipitation, we talked about quite a bit already today. The staff's view of the boric acid precipitation is that plant-specific analyses have to be done, taking the losses or taking the penalties for reduction in lower plenum mixing volume due to debris accumulation.

We've talked about upper plenum injection plants --

DR. WALLIS: What do you think about these mixing volumes not being affected by the debris at all?

DR. LANDRY: I'm sorry. How do you mean "not affected by the debris?"

DR. WALLIS: Well, --

DR. LANDRY: Mixing volume will be --

DR. WALLIS: Well, this sodium chloride stuff -- you're talking about boric acid precipitation? There's a mixing part of the analysis.

DR. LANDRY: Right. The mixing volume is

to be reduced --

DR. WALLIS: And this is assumed there's some mixing between the core and the lower plenum?

DR. LANDRY: Right.

DR. WALLIS: Which presumably would be inhibited by a layer of debris and we were assured by --

DR. LANDRY: And by reduction in volume --

DR. WALLIS: -- Tim Andreychek, I think, that there wouldn't be any effect and I was asking what you thought about that assertion.

DR. LANDRY: Well, we said that they have a methodology in the WCAP that says that you will take a penalty for or take a decrease for mixing volume based on debris --

DR. WALLIS: They will? I thought they were not taking any -- I thought they were already taking the penalty before there was debris.

DR. LANDRY: The WCAP refers to debris being in the lower plenum.

DR. WALLIS: I just didn't see any rationale for what's the effect of debris on mixing volume. I didn't see any rationale for any decision. It may well be okay. It's just that there somehow there seemed to be a missing link in the logic.

That's all.

MR. SCOTT: It says -- looking at the Conditions and Limitations on the safety evaluation, Number 4, "Existing plan analyses showing adequate dilution" -- that's what we're talking about here?

DR. WALLIS: Yes.

MR. SCOTT: "Existing plan analyses showing adequate dilution of boric acid during long-term cooling period have not considered core in the blockage. Licensees shall show that the possible core blockage from debris will not invalidate the existing post LOCA boric acid" --

DR. WALLIS: So, it's still sort of an open issue yet to be --

MR. SCOTT: Yes, you would say that we have left that to the plants to solve.

DR. LANDRY: That's why I said that this is a plant-specific analysis.

DR. WALLIS: And there isn't a proper guidance about how to compute this from the WCAP?

DR. LANDRY: The WCAP does have guidance.

DR. WALLIS: It does?

DR. LANDRY: Yes.

DR. WALLIS: It just asserts there isn't a problem.

DR. LANDRY: No. We said that we accept the guidance in the WCAP.

DR. WALLIS: Which is to assert there is no problem, right?

CHAIRMAN BANERJEE: What Graham is saying is what is the guidance in the WCAP? Maybe just to remind us.

MR. DINGLER: Why don't we go on and we'll find that?

CHAIRMAN BANERJEE: Why don't we move on while they look for the guidance?

DR. LANDRY: The upper plenum injection plants have been talked about quite a bit today. The staff view is that while looking at hot leg breaks with a UPI plant, that all the debris will be not swept through the upper plenum and back out, we disagree with the owners' group and believe that there will be settling of material that comes into the upper plenum, and also for the cold leg break, we believe that material will build up during the cold leg injection -- during the injection of the upper plenum. That debris must be accounted for in the analysis.

However, there are large margins, as have been shown with all the other analyses, and that we don't see where there's going to be sufficient quantity of material to inhibit or prevent continued cooling of the core.

DR. WALLIS: So, this is a qualitative thing? You don't analyze how much falls in and what it does? You just assert that there's a lot of margin?

DR. LANDRY: Right. And the material that comes in can be distributed evenly and it's still, based on the parts we're going to talk about next, --

DR. WALLIS: This is based on the fact that there's so little of it?

DR. LANDRY: There's so little, and when we start looking at points coming up in a couple slides on the local heat-up, that we don't believe it's going to have an appreciable effect.

CHAIRMAN BANERJEE: But still it's two inches or one inch of stuff, even with these relatively low bypasses that have been talked about, correct?

DR. LANDRY: But it would be evenly distributed or it would be distributed throughout the core, would not be a continuous layer across the top of the core.

CHAIRMAN BANERJEE: They may hold up on the first grid spacer, I believe, right?

DR. LANDRY: It may, but when we talk about the local effects, we'll get some input on that.

CHAIRMAN BANERJEE: But if it hung up on that the way that we saw in the German experiments, the potentially you could get, unless the spaces have higher open area or something, you could get a mat which are these space levels or the grid levels which would potentially block the core, right?

DR. LANDRY: We haven't seen the German material.

CHAIRMAN BANERJEE: Well, they would bring up flow, not down flow, actually.

DR. LANDRY: We'll look at the German material and see what they show.

CHAIRMAN BANERJEE: But more than the German material, you could potentially get a one-inch thick layer caught in this region, right? So that now you've only got the gravity head to drive it through or do you have actually pressure?

DR. LANDRY: We have flow, even with the UPI plant, you still have flow with the cold leg break. The flow comes into the upper plenum, down through the core. So, it's going to push material down, then it's going to come up through the downcomer and out the cold leg.

CHAIRMAN BANERJEE: This is just a gravity head difference between the cold leg break or is there more?

DR. LANDRY: This is --

CHAIRMAN BANERJEE: Is there a pressure in there?

DR. LANDRY: This is pressure. This is pump flow from the ECC injection.

CHAIRMAN BANERJEE: The whole plenum is full, upper plenum is basically full.

DR. LANDRY: Yes, and it's just going to be the pressure from the pump.

CHAIRMAN BANERJEE: Okay.

DR. WALLIS: This is a cold leg break and a hot leg break. The hot leg is connected to the upper plenum, isn't it?

DR. LANDRY: With a UPI plant, you inject into the upper plenum, whether it's a hot leg or a cold leg. So, if it's a hot leg --

DR. WALLIS: The pump isn't available --

DR. LANDRY: With the hot leg break, the injection, primary injection flow is going to come through after you've filled the vessel, the injection flow is going to come through the upper plenum and back out the hot leg.

With the cold leg break, the flow will come through, forced down through the core, up through --

DR. WALLIS: Then you've got the pump pressure to do that.

DR. LANDRY: Right.

DR. WALLIS: That's okay, but with hot leg break you lose the pump pressure, don't you?

DR. LANDRY: Some of it.

DR. WALLIS: It just goes out the break.

DR. LANDRY: Well, our contention is that not all the material is going to get swept out of the broken hot leg. Our contention is that there's going to be a percentage of material that's --

DR. WALLIS: What we're talking about is when that happens, what's the pressure that's driving the flow through the core? It's not the pump pressure because it's shortcircuited by the break, isn't it?

DR. LANDRY: Or in large part.

DR. WALLIS: Yes. So, you still got the question of what's the resistance and what's the driving head which we've asked so many times, and I just wonder if you aren't dismissing the question without doing a quantitative estimate.

CHAIRMAN BANERJEE: The hot leg break is

complex because I guess the liquid had to get down to cool the core and with the liquid will go some of this stuff which is entrained in it.

All right. Let's go on.

DR. LANDRY: Okay. One point that we found that was not in the WCAP but we've examined and questioned the owners' group about and that we've said needs to be put into the revision of the WCAP is the effect of swelling and rupture on blockage of the fuel that could occur during the LOCA.

Analyses which have been done typically for LOCAs indicate that you could have as much as 10 percent of the fuel that may swell during the LOCA. However, the analyses which have been done all indicate that that swelling is not going to be a co-planar swelling. It tends to distribute up and down slightly and not be co-planar, so that you would still not get a 10 percent blockage of the fuel on the same plane from swelling of the fuel.

We agree with the owners' group that there would still be acceptable core cooling, in spite of blockage due to swelling and rupture of fuel and even any capture of debris material on a jagged edge of a ruptured fuel rod, but we do insist that the owners' group in a revision to the WCAP include in their discussion of fuel swelling and blockage and rupture.

A local heating of fuel rods. The local heating of the fuel rods can occur due to build-up of an oxide layer, a crud layer that was pre-existing, plate-out of debris, and plate-out of chemicals, and build-up of debris between the fuel rods and the spacer grid.

The staff position, as we've discussed a couple times already today, is that local heat-up of a cladding should not result in a peak cladding temperature that exceeds 800 degrees following the initial core quench and reflood.

Cladding oxidation estimation is required by 10 CFR 50.46, Part B, Paragraph 2. The oxidation that is calculated is intended to include preaccident oxidation as well as the oxidation that occurs during the accident.

We sent out an information notice in the late 1990s informing the licensees that when they calculated the oxidation post-LOCA, that oxidation was to be the total oxidation which would include the oxidation that existed as a relative result of normal operation.

WCAP-16793 prescribed oxidation for input to LOCADM to be 17 percent. We assume that the oxidation that you input LOCADM is at the limit of the regulation.

The analysis which Tim already talked about this morning --

DR. WALLIS: Wait a minute. There's two criteria. There's core-wide oxidation and maximum local oxidation.

DR. LANDRY: There's not core-wide oxidation.

DR. WALLIS: There's not core-wide oxidation?

DR. LANDRY: No, there's not. There is hydrogen generation that would be --

DR. WALLIS: Isn't that the same thing?

DR. LANDRY: There's hydrogen generation that would be equivalent to --

DR. WALLIS: Right, right. Isn't that --

DR. LANDRY: -- a 1 percent oxidation core.

DR. WALLIS: -- what it is? I've always thought of it as core-wide oxidation.

DR. LANDRY: It doesn't say you have to calculate core-wide oxidation.

DR. WALLIS: But isn't it the same reaction?

DR. LANDRY: It's the same reaction.

DR. WALLIS: So, I was just saying there are two criteria.

DR. LANDRY: For the 1 percent --

DR. WALLIS: One is core-wide and one's local, right?

DR. LANDRY: Maximum local oxidation, 17.

DR. WALLIS: All right. And 17 is the maximum local and below, right? All right.

DR. LANDRY: And the Paragraph 3, Criterion Number 3, is a hydrogen-generation criterion. It says that you can't have more hydrogen generated than if you had oxidized 1 percent of the core, 1 percent of the cladding that covers active fuel. So, it's even more specific. It's not 1 percent of the total cladding.

The analysis that was done or the WCAP assumed the thermal conductivity for the oxide layer of 1.61 BTU per hour per foot per degree Fahrenheit, and as a sensitivity, the owners' group did two calculations. They did an analysis assuming a 100 micron layer of oxide and an analysis assuming a 150 micron layer of oxide, a 50 percent increase.

They found that that increase in oxide layer only resulted in a temperature increase of two degrees Fahrenheit. So, the temperature of the cladding is relatively insensitive to the thickness of the oxide layer on the cladding.

Just by way of calibration, we looked at some of the fuel that has come out of very high burn-up assemblies. Some of these are lead test assemblies. That's why they're in excess of 60 to 62 gigawatt days per ton, and we found that with cladding, the modern cladding, we're seeing oxide layers that are only on the order of 10 to 43 microns and this is high burn-up.

We see cladding from the very old Zirc-4 which is no longer in use that ended up with a 95 micron layer after the third cycle burn-up, but I would point out that that old version of Zirc-4 is no longer in use in the United States.

So, the corrosion layer that would occur from normal operation would still be well below the amounts that were assumed in the analysis by the owners' group.

Heating of the fuel rods due to debris deposition. This is looking at deposition of debris on the fuel rod in the region of the spacer grid. With the spacer grid, the fuel rods that are normally held a 100 mils apart could get as far as a 110 mils apart in some of the spacers when they're pushed at their limit.

The owners' group did two analyses, one with a 150 mil deposition on the fuel and another with a layer that was only 15 mils, half of the thickness of the separation between the fuel rods.

Using a conservative thermal conductivity of .1 BTU which is a thermal conductivity for dry insulating material, the calculated peak cladding temperatures in the two cases were 738 degrees Fahrenheit for the 110 mil layer and 474 degrees Fahrenheit for the 50 mil layer. Both of these are well below the 800 degree imposed limit.

DR. WALLIS: Isn't this bridging -- doesn't it depend on the extent of the bridging? It's not just one little bridge, is it? I mean, you can just block up the region between the fuel rods completely.

DR. LANDRY: And that's what the 110 mil bridge would do. It would completely bridge --

DR. WALLIS: So, how does the heat not get out? It gets out axially or something?

DR. LANDRY: In this case, the calculations that were done for this were done with LOCADM which only calculates radial heat transfer. It does not calculate axial heat transfer.

DR. WALLIS: So, where does it go to if the cap is full of debris?

DR. LANDRY: This is bridging on one side of the rod. Heat would still be able to get around.

DR. WALLIS: So, it gets cooled on the other side?

DR. LANDRY: Would be able to -- the other side of the rod would result in sufficient cooling to keep the temperature behind the debris built up to a 738 degrees.

CHAIRMAN BANERJEE: I think we are going to have to speed up a little because --

DR. LANDRY: I'm trying.

CHAIRMAN BANERJEE: -- chemical effects.

DR. LANDRY: I am trying.

CHAIRMAN BANERJEE: Right.

DR. LANDRY: This next one we'll skip because we already discussed it at length. This is the insulation tests that were run in the 1970s.

CHAIRMAN BANERJEE: Right.

DR. LANDRY: The crud layer. Crud was assumed to be present in a layer of 50 microns for the first cycle and a 100 microns for the second and third cycle. The maximum crud layer that has been measured on any fuel in the United States has been a 127 microns and that was on a plant prior to imposition of tech specs that require checking the fuel between fuel samples and a cleaning and a chemistry control that have prevented build-up of crud layers of that magnitude since that point.

Eliminating crud thermal conductivity. That has been referenced. We already talked about. We talked about the methodology for calculating build-up of scale and to get to the bottom line, the calculation which Tim had talked about earlier, combination calculation with a 100 microns of oxide, a 100 microns of crud and 50 mils of chemical precip only resulted in peak cladding temperatures of 560 degrees for the .360 rod, 713 degrees for the .416 rod, and 714 degrees for the .422 rod, all again are below the PCT limit of 800 degrees Fahrenheit.

And now --

CHAIRMAN BANERJEE: How sensitive is that to the 60 mils of crud?

DR. LANDRY: How sensitive is it --

CHAIRMAN BANERJEE: To the temperature? Like if you had 60 mils of crud, would it make a big difference? Not crud, the chemical deposits. If you go back to the previous slide. So, you say 50 mils of chemical deposits.

DR. LITMAN: Tim, didn't you folks do an estimate that it would take 90 mils?

MR. ANDREYCHEK: That's correct.

DR. LITMAN: Yes, it will take 90 mils to get up to 800 degrees.

MR. ANDREYCHEK: That's correct.

DR. LITMAN: Yes.

CHAIRMAN BANERJEE: What happens to the 714?

DR. LITMAN: At -- I'm sorry?

CHAIRMAN BANERJEE: What happens to the 714 there? The 714.

MR. ANDREYCHEK: The 90 mils was on a thin rod.

DR. LITMAN: Yes, it was.

MR. ANDREYCHEK: The .42 inch rod and the 714 degrees, obviously you don't need quite as much debris over the 50 mils to get close to 800 degree F temperature, but again at that point, you're already bridging and you've got --

CHAIRMAN BANERJEE: You have other problems when you --

MR. ANDREYCHEK: Yes.

CHAIRMAN BANERJEE: You ran a 90 mil

deposit chemical precipitate on a rod of some size.

MR. ANDREYCHEK: Right.

CHAIRMAN BANERJEE: What did you find there?

MR. ANDREYCHEK: Well, I'd suggest if you take a look at that table that I provided you this morning --

CHAIRMAN BANERJEE: Yes.

MR. ANDREYCHEK: -- that extrapolated out, that would give you an approximation of the temperatures. That was for a thinner rod, on the order of the .36 diameter rod. You can take a look and run that out for additional thicknesses and that would give you an approximate answer to the question you're asking. What does it come up? Just stretch it straight on out and that would give you an answer.

CHAIRMAN BANERJEE: But give me the answer to the question that, Graham, you've made already without extrapolating.

You said you did a 90 mil thickness, right?

MR. ANDREYCHEK: And that gets you close to the 800 degree temperature.

MR. KLEIN: Depending on the fuel diameter, 60 to 90 mils of chemical scale will get you to that 800 degree value.

MR. ANDREYCHEK: That's correct.

CHAIRMAN BANERJEE: I think that's a clearer answer. 60 to 90. So, 50 is just below that. Okay.

MR. DINGLER: Before Paul gets in, your question on the boric acid dilution, right now the maximum plenum volume considered in a plant, current license basis for boron dilution is 50 percent of the lower plenum.

Some plants consider no volume of the lower plenum, others up to 50 percent.

DR. WALLIS: And there is no volume from the core at all?

MR. DINGLER: That was the lower plenum in relationship to mixing. That was your question, I believe.

DR. WALLIS: There's no mixing between the core and the lower plenum?

MR. DINGLER: The maximum that some plants have takes credit that they need 50 percent volume of the lower plenum to provide the --

DR. WALLIS: This is going to be affected by the crud. What we're concerned about is mixing between the core and the lower plenum. I thought that was the issue.

MR. DINGLER: That's not how I understood the question. Sorry.

CHAIRMAN BANERJEE: So, the question that was posed originally was how do you account for the crud inhibiting mixing between the core and the lower plenum? That's how I understood the question. And what guidance? Are you asking is there any guidance in the report or not, how to treat that?

MR. ANDREYCHEK: I understood the question to be if you're building up the debris that's settling out in the lower plenum, how can you -- you know, what's your rationale for saying that it doesn't affect the mixing volume, and what the guidance that we've given into WCAP says, based on what we know today of licensing basis mixing calculations to mitigate boric acid concentration build-up, some plants use no more than 50 percent of the lower plenum as part of their mixing volume to mitigate boric acid --

DR. WALLIS: Now I understand that as far as the mixing of the lower plenum goes, but I thought there was mixing between the core and the lower plenum. Maybe I was --

MR. ANDREYCHEK: That's correct.

DR. WALLIS: Isn't that inhibited by debris?

MR. ANDREYCHEK: It's -- again, we were looking at settling in the lower plenum.

DR. WALLIS: But doesn't making 50 percent of the lower plenum -- it doesn't say anything about the interchange between it and something else.

MR. ANDREYCHEK: Let me finish. And the guidance in the WCAP says if you collect more than -- if you fill more than 50 percent of the lower plenum with debris, then you need to look at and evaluate what effect that has on your mixing volumes and how much credit you can take for the mixing volume.

DR. WALLIS: Well, we seem to be at cross purposes because the question we asked doesn't seem to be being answered.

MEMBER ABDEL-KHALIK: It is not how much water is available for mixing. It's whether or not mixing is possible.

DR. WALLIS: Between it and the core.

CHAIRMAN BANERJEE: And how is it inhibited by the --

DR. WALLIS: Maybe we should move on.

CHAIRMAN BANERJEE: Well, with the five cubic feet of debris getting through, obviously there isn't a big effect on the mixing volume, but --

MR. DINGLER: And that's why we made that conclusion.

CHAIRMAN BANERJEE: Right. But the issue is does the -- is there any effect of the debris bed being formed on the mixing between the lower plenum and what's happening in the core?

MR. SCOTT: Would that be based on an assertion that the debris bed would capture boron? Is that where you're going with that?

CHAIRMAN BANERJEE: We don't know. We're just asking if --

MR. SCOTT: Because we already talked about the question of whether we believe that there is an impenetrable or close to impenetrable debris bed. So, leaving that question aside, in other words, we assert that there is flow into the core, then where would the stoppage of the boric acid be? Would the boric acid be hung up in the bed somehow? I'm not sure where you're going. No.

So, then this is the same question as we talked about before about whether a thin bed or a bed of debris covering the whole bottom plate would occur, yes?

CHAIRMAN BANERJEE: Yes.

MR. SCOTT: Okay. And we've already talked about what our rationale is and we heard your question on that.

DR. WALLIS: It doesn't need to cover the whole -- we talked about mixing, I thought, between the lower plenum and the core and it depends upon how much area is blocked and how extensive the blockage is.

MR. SCOTT: And as you heard from when I read to you that condition and limitation, I don't believe the topical report is --

DR. WALLIS: I think we've had enough presented. I don't think we're getting anywhere with this.

DR. LANDRY: I don't think it matters at all for some plants because, as Mo said, some plants don't take any credit for mixing in the lower plenum to begin with. For those plants, it doesn't matter. It's only those plants that take credit for mixing in the lower plenum where there would be a question, is there sufficient blockage to prevent mixing --

DR. WALLIS: What kind of mixing? Mixing in the lower plenum isn't the issue.

CHAIRMAN BANERJEE: There -- it is a complicated problem because mixing depends on the velocity that, you know, is in there to mix it and if you've got a very, very low velocity, it depends when the boron is injected. I mean, there's a whole lot of issues that start to come up at this point.

If you don't need the credit, it doesn't really matter, but if you do need the credit, then, you know, what happens to the mixing patterns because you've got this debris bed now sitting there, that's -- you know, and you're getting a very low velocity through the debris bed.

MR. SCOTT: And based on what I read in the SE, we have not taken that on. Now, if --

CHAIRMAN BANERJEE: It may not be an important issue, but I just --

MR. SCOTT: Well, I don't know. I mean, I'm seeing here that that has been left to the licensee to deal with. Now, if that's incorrect, if there's information in the topical report that the owners' group believes resolves this issue and the staff evidently didn't agree or in some manner said that the plants need to do it individually, that's the way I read the SE.

CHAIRMAN BANERJEE: When does this mixing occur in this process? After the switch-over or before? I mean, I don't have a good feel for when that happens?

MR. ANDREYCHEK: The process, the use of mixing between the core region and the lower plenum occurs once you've begun the recirculation from the containment sump until the time that you establish hot leg flow or an alternate flow path for some plants.

CHAIRMAN BANERJEE: Then it's a valid question because now you've got formation of a bed, if you like, and the velocities are low, becoming quite low, and the turbulence is low. So, I don't know where it's going, but I would think it would affect the mixing pattern somewhat, right?

MR. DINGLER: I guess I don't understand the question because the velocity --

CHAIRMAN BANERJEE: How is the mixing done?

MR. DINGLER: The velocity is going to be low and turbulence is going to be low because the velocities are low, no matter if I have a bed being formed or not.

CHAIRMAN BANERJEE: Without the bed being formed, you have a much higher velocity, right? I mean, you --

MR. DINGLER: Actually, I've got the same amount of flow.

CHAIRMAN BANERJEE: No. You just said that you're getting only 5 percent of the flow, right? So 95 percent of the bed is blocked. So, if you're getting only 5 percent of the flow, then the velocities are lower in the lower plenum, at least I haven't thought this through, I have to look at how this mixing is done and all this sort of stuff.

MEMBER ABDEL-KHALIK: The driving head is essentially the same, but you have an added resistance at the inlet to the core, therefore you would expect the flow rate to be less.

CHAIRMAN BANERJEE: How is the mixing done? I mean, what's the physics of it? What happens there?

MR. DINGLER: Through gravity head on both scenarios.

CHAIRMAN BANERJEE: So, there's no convective effect in the mixing?

MR. ANDREYCHEK: The mixing is density driven, density difference driven. You've got cooler water on the periphery of the fuel that will tend to drop down the baffle barrel region and go down, you know, down along the periphery and the hotter portion of the core is in the center. So, you will tend to have currents rising up through the center of the core. So, you get somewhat of, I want to call it, a toroidal or doughnut pattern of mixing in the core for the time period between you initiate recirculation from the sump until you initiate recirculation through the hot leg and begin to flush the core. That's the fundamental mixing pattern for a two-loop and a three-loop pressurized water reactor.

DR. WALLIS: But the mixing pattern would be changed if you had flow which was only distributed over part of the core.

MR. ANDREYCHEK: It might potentially would be changed, yes.

DR. WALLIS: So, I think there are some questions about the mixing that someone should probably answer.

CHAIRMAN BANERJEE: Yes, I think we should move on. It's a very complicated thing and I don't know if this bed has any effect or not. So, let's put it aside for the moment and move on to chemical effects.

MR. KLEIN: Okay. If it would please the committee, we could just skip right past the chemical effects and --

CHAIRMAN BANERJEE: It would please the committee for sure.

MR. KLEIN: The next dozen or so slides are going to address the staff's review of chemical effects and we really have two different pieces that we wanted to touch on. Although the primary objective of the presentation is to discuss the WCAP-16793, we thought it was important to first talk a little bit about WCAP-16530-NP which provides the chemical source term, if you will, for the in-vessel evaluation.

Next slide. If you recall, we last briefed this subcommittee in May on WCAP-16530. At that time, you know, the staff review was still in progress. Since that time, we have completed our review and the safety evaluation is available as of December.

CHAIRMAN BANERJEE: Has the report been issued now?

MR. KLEIN: Yes, it is issued in final form, I believe. Isn't that true? There's an A attached to that now.

MR. DINGLER: Right now, we're still working on getting that 16530-A to you. We had a little problem of getting the right paper signed.

MR. KLEIN: We think it's close then.

CHAIRMAN BANERJEE: Okay. Was the peer review -- did it affect any aspect of this? It was on a different subject?

MR. KLEIN: Yes, it absolutely did. During the course of review, the peer review committee met with Research and some of the issues that they raised were then incorporated into the RAIs that were addressed to the owners' group on this particular WCAP.

CHAIRMAN BANERJEE: Okay.

MR. KLEIN: So, I think I'll try to touch on a very high level on 16530 and you can ask whatever depth of questions you'd like on that particular WCAP, but in essence, this WCAP relied on an industry survey of all the PWRs to determine what materials should be present in containment that might interact with the post-LOCA environment and then individual key pieces of the WCAP included dissolution tests which provided the chemical source term.

They also did precipitation tests and determined what type of precipitates might form and then the third major piece was particle generator which essentially is a method for creating surrogate chemical precipitates that might be used in subsequent integrated head loss tests by the industry.

Next slide. As you're all aware, the technical topics within this WCAP chemical effects are quite complex and so the staff did seek assistance for this particular topical review and in particular, we were assisted by Argonne National Laboratory and also by Dr. Bob Litman who's seated to my right here.

Bob, I should also mention, was a member of the peer review panel. So, he not only assisted with this review but at that time, he had the entire background of the NRC-sponsored tests up to that point.

During the course of our review of this particular WCAP, we did conclude that some confirmatory testing was needed in order to help us complete the review and there were two major parts to those tests. We had a set of tests done at Argonne National Lab and in particular that consisted of both bench-top tests and head loss tests within their vertical head loss loop, and then we also did some supplementary dissolution tests at Southwest Research Institute.

This slide I'd like to touch in particular on some of the conservative assumptions that are made in 16530. I think as part of the staff review, we stepped back and there are a number of uncertainties involved in the chemical effects area and so part of our approach in the review was to try to determine if the built-in conservatisms within the WCAP bounded what we thought were the major uncertainties and so if you look at particular aspects of the WCAP, one of the biggest conservatisms that they make is that all dissolved aluminum and all calcium that's dissolved in the presence of phosphate is assumed to precipitate and they also make that assumption that precipitation occurs instantaneously, so that there's no really consideration of kinetic effects or other things.

So, we think it's conservative both with respect to the total amount of aluminum, for instance, that would precipitate because there is solubility factor that's a function of pH and temperature and also by assuming instantaneous precipitation and performing an integrated head loss test with that assumption, you are applying the chemical precipitates at a point of minimum NPSH margins.

The WCAP also does not consider passivation of aluminum corrosion by either phosphates or silicates and subsequent tests and literature that's available publicly would indicate that both phosphates and silicates can have dramatic impacts on the amount of aluminum that corrodes in these environments.

As part of the confirmatory tests that we did at Argonne National Lab, they took small amounts of the WCAP surrogate precipitate and then they performed vertical head loss root testing. I guess there were a couple concerns that the staff had.

One, we wanted to try to understand whether the two different aluminum-based surrogates in the WCAP, the sodium aluminum silicate and the aluminum oxyhydroxide, behaved similarly and the reason that that was important to us, the WCAP assumptions are based somewhat on thermodynamic calculations and based on our review, we didn't think we could necessarily conclude that those predictions for relative amounts of each of those precipitates would be accurate under a more dynamic kinetic-type situation.

So, the goal of the head loss test was to see whether those two precipitates behaved similar, such that the relative predictions by the WCAP model would not be important, and we also wanted to benchmark these precipitates against precipitates that had formed during earlier ANL head loss testing that was reported in NUREG-6193 and has been, I think, briefed to this committee maybe two years ago now.

Within the limited scope test at Southwest, they had a different objective. One, we wanted to try to test some of the assumptions within the WCAP, whether -- we had two different types of tests. One was to take some of the materials that were not tested within the WCAP. The WCAP, they made assumptions. They grouped the plant materials into different categories and then they tested a representative material from each of those categories.

So, we wanted to try some of the other materials that were not tested and we also wanted to repeat some of the test conditions that -- where the WCAP testing had produced precipitate to try to get a measure of how much variation there might be for tests run at a different facility but using the same materials and concentrations.

CHAIRMAN BANERJEE: Which vendors did the testing?

MR. KLEIN: The Argonne National Lab did the bench-top test to evaluate the WCAP surrogate formation and also the vertical head loss loop test, and Southwest Research did the leaching and precipitation tests to try and confirm some of the data in the topical report.

CHAIRMAN BANERJEE: The WCAP surrogate precipitate tests, you say Argonne did some vertical head loss --

MR. KLEIN: Yes.

CHAIRMAN BANERJEE: -- and vendors did this as well?

MR. KLEIN: Yes.

CHAIRMAN BANERJEE: Which vendors were they?

MR. KLEIN: Well, there's -- let me make sure I communicate this clearly.

The NRC-sponsored tests were the ones done at Argonne National Lab. The vendor tests would refer to the nuclear industry vendors that are testing with the WCAP surrogate and those tests could include vertical head loss loop tests or larger-scale tests in flumes or tanks, depending on the particular set-up.

CHAIRMAN BANERJEE: This is what you were referring to earlier, saying they found lower pressure losses in general?

MR. KLEIN: Yes, with the WCAP surrogate. I think that the other thing that the industry tests have shown for people that -- for licensees that have decided the WCAP methodology is too conservative, some of them have done tests where they essentially run another ICET, only instead of a control temperature, I mean a constant temperature test, they followed a post-LOCA temperature profile with all scale plant materials and the buffer and everything else and those tests have also shown that the WCAP predictions are a conservative for the total amount of precipitate that forms.

The Argonne National Lab tests showed that very small quantities of the WCAP surrogate within a vertical head loss loop test would cause very high head loss.

CHAIRMAN BANERJEE: And the reason is attributed to some of the precipitate settling out in the other tests or why are the tests different? In the vertical one, all the precipitate ends up in the bed, right?

MR. KLEIN: That's correct. The vertical head loss loop test assures 100 percent of the precipitate makes it to the strainer surface. The industry tests, I think we've been working to ensure that they use whatever is necessary to get all the precipitate to the strainer, but even under those cases when you go to larger test flumes and tanks, some of the chemical precipitate does not end up deposited within the strainer. It might stay in solution and then at the end of the test settle down to the end of it, to the bottom of the test tank.

But I think it's also somewhat a function of the complex geometry in the larger strainers and how the debris bed forms on those strainers compared to the bed that might form on a flat plate.

MR. DINGLER: Also, let me put it in perspective. If you don't use the chemical and you only did a vertical head loss, this with particulate and fiber, you'll see a higher head loss with that test against the complex screens that were seen in the flume test, also.

So, it's not surprising that --

CHAIRMAN BANERJEE: Is it the complexity of the screen, scale of the screen, or the fact that gravity acts in a different --

MR. DINGLER: I think it may be all of it. In other words, the screens -- some of them screen. What you see in the vertical head loss test is a screen that you input the particulate and it all forms on one area. On some of the complex screens, you won't see a uniform bed being formed. You'll see thicknesses in one area, less thickness in the other and it's a combination, I say all, but the bottom line was the head loss and the vertical head loss test without chemicals was showing higher than we do without chemical in a flume test, also.

CHAIRMAN BANERJEE: Okay. Keep going.

MR. KLEIN: To just hit the high points from this slide, I think if we could back up one, I think --

CHAIRMAN BANERJEE: Let me ask you to write a letter on this, right?

MR. KLEIN: No. No, we're not. As part of the confirmatory tests that I think we convinced ourselves that the WCAP surrogate was very effective at producing a high head loss and it also had representative settlement properties.

Southwest's tests showed that, you know, even repeating some of the Westinghouse tests where precipitate formed, we didn't see precipitate in the Southwest tests. So, we thought overall that there was a number of things pointing to the conservativism in the technique which was confirmed by some of the subsequent vendor 30-day integrated head loss tests where they put all the materials into the right solution at temperature.

Next slide. I wanted to touch on some of the safety evaluation condition limitations on this slide.

As you're aware, there were a number of technical issues that were raised by the Chemical Effects Peer Review Committee. At this point, there's a number of those technical issues has been pared back considerably.

There's additional scoping analyses that the Office of Nuclear Regulatory Research had a contract with Pacific Northwest National Lab to evaluate the remaining peer review panel issues. So, within this safety evaluation, I think we felt very comfortable with the overall industry methodology but we wanted to also leave a reminder that it's possible that subsequent testing or analysis that comes out of that peer review issues could impact this. So that's the first bullet.

Moving on, I think this particular safety evaluation did not address some of the follow-up refinements that industry has made available to the base model WCAP and we have commented on some of those refinements outside of this particular safety evaluation, but in particular industry did additional tests to evaluate passivation by silicates, by phosphates, and also to evaluate solubility of some of these precipitates.

One of the things that we did when we looked at the release --

CHAIRMAN BANERJEE: This was sort of alluded to in our May meeting, but I don't think there was --

MR. KLEIN: Yes.

CHAIRMAN BANERJEE: It wasn't out at that time, right?

MR. KLEIN: That WCAP is out and what the staff tried to do was provide comments in the Chemical Effects Evaluation Guidance that we provided to the industry so that as licensees were trying to put together their GL supplements, they had a pretty good understanding of the staff's thoughts on some of these various refinements, and I guess from our perspective, some of these are more easily addressed than others.

Some of them get quite complicated. For instance, the silicate inhibition of aluminum corrosion, you have to presuppose a certain amount of material in the break and then you have to assume certain amounts of dissolution from that material and then you have to reach sufficient levels of silicate that are then transported to the aluminum to inhibit corrosion and so some refinements seem very difficult to the staff to try and implement. Others, where you might have a source of phosphates, such as trisodium phosphate already as a buffer in containment, seem more easily supported.

The next bullet, we did impose a condition and limitation for people that wanted to try and use a time-based addition of WCAP precipitate. We looked at the aluminum release rate equations in the WCAP. They tended to fit a whole set of data, including ICET, and that fit to the ICET data is more of an averaged fit over 30 days.

When you look at the actual ICET behavior, you see a very active corrosion stage during the initial half, followed by a passivation where there's very little aluminum corrosion. So, we thought it would be very appropriate if time-based valuation was attempted by a licensee, that they would need to account for that type of behavior rather than using an averaging approach.

We also applied a more stringent precipitate settlement acceptance criteria compared to the original one suggested in the WCAP and that was based on several different things. One was one is the strainer vendors decided to use a test protocol that included debris settlement. So, the main objective switch from getting debris and precipitate to the strainer to try to settle out debris and precipitate prior to the strainer. So, we thought that much more stringent settlement criteria for precipitate was warranted in that case.

In another, the final bullet here had to do with sodium aluminum silicate solubility. We noticed as part of the ANL confirmatory tests that if you added the sodium aluminum silicate to tap water, you had one behavior. If you added it, for example, to deionized water, there was some solubility effect.

Our understanding is that all licensees are performing these larger-scale tests in more potable water-type environments, so this might not be applicable to them, but for someone that was running a test in a deionized water, they would need to account for that solubility effect when they were determining how much precipitate to add to the particular integrated head loss tests.

CHAIRMAN BANERJEE: Okay. Now we come to -- so, let's try to get out of here by 6 o'clock at the latest.

MR. KLEIN: Okay.

CHAIRMAN BANERJEE: Which means that we have to keep the questions down, I think.

MR. KLEIN: I will try to move through these relatively quickly.

Next slide. Now we're discussing the --

CHAIRMAN BANERJEE: We want about 15 minutes to sort of sum up and talk.

MR. KLEIN: Okay. I understand. You will not have to slow me down.

LOCADM is the code that's used within the WCAP to evaluate the chemical effects and LOCADM was chosen since it can address the non-uniform chemical deposition due to variations in core power and whether the local conditions predict boiling or not within the core.

Some of the other sensitivity codes that we saw in the earlier presentations were more assuming uniform deposition of chemical scale and I should note that the maximum deposition occurs when local mode conditions predict boiling.

CHAIRMAN BANERJEE: Who developed this code? Whose code is it?

MR. DINGLER: The owners' group did.

CHAIRMAN BANERJEE: The owners' group?

MR. DINGLER: Yes.

CHAIRMAN BANERJEE: Okay.

MR. DINGLER: They consider it a spreadsheet.

MR. KLEIN: As far as the assumptions for the chemical source term, the WCAP uses the data for the dissolved materials from 16530 as the starting point for all the materials that can be deposited to the fuel and this is, we feel, a conservative assumption. They neglect possible settlement of any of this debris elsewhere. So, the WCAP-16793 input is the 16530 chemical spreadsheet output.

DR. WALLIS: Do you believe that the LOCA scale forms underneath the pre-existing crud?

DR. LITMAN: Yes, the premise for that is that the crud on the surface of the fuel actually does have some small defects in the channels and the water that comes to cool the surface of the fuel gets down in those channels, boils at the surface of the actual cladding and as that occurs, the residual materials, residual dissolved solids evaporate underneath the existing crud.

There's actually very good industry evidence for this already. The program has taken several slices of crud on fuel rods.

DR. WALLIS: So, there is evidence?

DR. LITMAN: Yes, definitely evidence to prove that, yes.

DR. WALLIS: Thank you.

DR. LITMAN: Sure.

DR. WALLIS: That'S what concerned me, that this wasn't just somebody's idea.

DR. LITMAN: No, not at all.

DR. WALLIS: Okay.

MR. KLEIN: Okay. The chemical source term for the LOCADM couples what's in the vessel to the sump. As you deposit species on the fuel, it tends to increase the amount in the sumps that are then delivered back into the vessel. It assumes no deposition occurs on surfaces outside the core and that all material that's transported to the fuel clad surface during boiling is deposited and it also assumes that there's -- you know, once formed, the deposit is not thinned by flow, dissolution or any other means and that any type of particulate carried into the deposit stays in the deposit.

The approach taken in the LOCADM within the WCAP. Two different thermodynamic programs were used. The OLI StreamAnalyzer, which you might be familiar, was the same one that was used for some of the predictions for the ICET experiments, and also HSC Chemistry.

The objective of these program runs were not to identify exact species that were formed but they were used as a guide for the type of materials that could form on the fuel and then given this class of materials that could form, the owners' group selected a bounding chemical deposit thermal conductivity and they made that selection based on an assumption that a sodium aluminum silicate deposit would form on the fuel and they chose a lower bound value of thermal conductivity for that material and that bounded all the other materials that they had thought could form based on these thermodynamic programs.

Next slide. Just to provide some perspective on the thermal conductivity value that's assumed of about .1, here's a range of thermal conductivity values from a number of other different materials. The range provided for fiberglass varies from a dry fiberglass mat of .05 to fiberglass that's saturated with an equal mixture of water and steam of .6.

Some of the other materials that are out there specifically for insulation purposes, like composite foam, had values of .09 to .1, so you can see that the value they chose is closer to the insulating-type materials than it is to some of the calcium-forming materials that might be the more probable thing that would form in the post-LOCA environment. The calcium carbonates and sulfates had much higher thermal conductivity values.

Next slide. So, these next couple slides get into our rationale for accepting their chemical effects evaluation. We think that the use of the total dissolved materials from the 16530 model and assuming that's all available and deposited on the fuel is a quite conservative assumption.

You know, in one case, outside of the fuel, we're making the industry assume that all this stuff precipitates and collects on the debris bed that's on a strainer and then they have to deal with that issue in head loss space and here it's just the opposite. We're assuming everything has stayed in the solution, has not deposited within a containment or settled, has not got hung up on the debris bed, didn't plate out on a heat exchanger or anywhere within the reactor vessel, other than in the fuel, and we also --

DR. WALLIS: Can I ask you now about this? You're saying that LOCADM gives a very conservative estimate or there's a big margin between what it predicts and what you need to get high temperatures.

MR. KLEIN: Yes.

DR. WALLIS: Suppose that the whole basis of the calculation is physically incorrect. Now, is there some check that the whole thing is right?

MR. KLEIN: I think the one experiment that they did to try and validate the LOCADM code was to run LOCADM for --

DR. WALLIS: Boron. They did it for boron.

MR. KLEIN: I think it was for a -- yes, they did it for boron. You're correct. That was to compare it to, I think, a safety-related code, but they also took a LOCADM and ran the code for an experiment that had calcium sulfate salt and they compared the LOCADM code to what that particular experiment had showed.

DR. WALLIS: I just saw the boron one. Maybe I missed the other one.

MR. KLEIN: The very last slide.

DR. WALLIS: Oh, okay. So, there is some good evidence that it's unreasonably good?

MR. KLEIN: This was within the WCAP. Part of their validation, they had calcium sulfate in this case of deposit on an electrically-heated tube in a laboratory test and they tried to benchmark against that test to run the LOCADM code and they determined that the LOCADM predicted a deposition rate that was about five times of what was measured experimentally. That's part of their basis for why they think it's a conservative deposition, and I don't know if Art Byers is here and wants to add anything to that particular discussion.

CHAIRMAN BANERJEE: What is the simulation? What is the simulation there? The one which is below the data?

MR. KLEIN: Yes, that -- simulation was the author trying to predict the experimental results with their own code. So, there was actually a paper that had the experimental data from the mixed salt deposition. Within that paper, the author had developed their own predictions of what might happen and then independent of that, the owners' group had run the LOCADM code to see what might happen with the LOCADM predictions compared to the experimental evidence.

CHAIRMAN BANERJEE: Who was the author, and where was it published?

MR. KLEIN: We can get that to you.

CHAIRMAN BANERJEE: Yes. Well, you can send it.

MR. KLEIN: Yes, we'll have that paper. We'll send you a copy.

CHAIRMAN BANERJEE: It was in a peer-reviewed journal?

MR. KLEIN: I don't have the details off the top of my head. I believe it was in -- presented at a heat exchanger conference, but if the people from Westinghouse can help me out.

CHAIRMAN BANERJEE: Oh, I saw it as a reference in your WCAP then.

DR. LITMAN: Yes, it was referenced in the WCAP.

CHAIRMAN BANERJEE: Yes, a lot of these papers which are referenced are very hard to get hold of. They're in some obscure meeting or some place and I have no way to find them to look at them. I remember that. So, it would be useful to get a copy of that paper to look at, if you can provide it.

MR. KLEIN: It's a 2003 ECI Conference on Heat Exchanger Fouling and Cleaning. We have the author and we have the paper, so I'll make sure you get a copy.

CHAIRMAN BANERJEE: Thanks. Even more obscure references than that, but there's no way you can ever get them. I can give you a list of them. All right.

MR. KLEIN: Yes, I think we're ready for the next one.

If you look at some of the sensitivity calculations that Westinghouse had performed, they took a highest power fuel rod, they took a decay heat level at the time of switch-over to recirculation and then they assumed a 100 micron oxide layer, 100 micron crud layer, and a 50 mil chemical deposit, and this is just not reality since at the time to recirculation, you're really drawing off a pure water source.

So, we think that that's clearly conservative to lay down an instantaneous chemical deposit of very low thermal conductivity and even under these conditions with no axial heat transfer, they were able to show that a surface temperature was less than 800 degrees.

LOCADM did have a sample calculation within the WCAP. In this case, they ran a high, a very high-fiber plant. It also included a large amount of calcium silicate. So, from a chemical standpoint, there was a high-end debris load, if you will, and during that sample LOCADM calculation, they determined that there was a 10 mil maximum chemical deposit.

DR. WALLIS: Is it significant that there was 7,000 cubic feet of fiberglass? I would think once you get enough of it, it doesn't make any difference anymore.

MR. KLEIN: I would think that you're right after you get a certain amount. So, I would just --

DR. WALLIS: It's just that much.

MR. KLEIN: I would look at that as a very high-end fiberglass load, not necessarily the absolute number, but I think overall conclusion is that there is quite a margin between, you know, the chemical deposit that is predicted for this high-end chemical load and the amount of chemical deposit that would start to challenge the 800 degree acceptance criteria and so if there's no more questions, I was going to turn it back to Ralph at this point.

DR. WALLIS: 7,000 cubic foot looks like more than pick-up truckloads. 7,000 cubic feet is a bit hard to imagine.

MR. DINGLER: We wanted to make sure we were --

DR. WALLIS: This room? No, it's not.

MR. DINGLER: We wanted to make sure we were bounding.

DR. WALLIS: It's not quite -- it wouldn't quite fill this room. Okay.

CHAIRMAN BANERJEE: So, I think we are back to you, Ralph, right?

DR. LANDRY: Right. We're going to the conclusions very quickly now.

The application of the WCAP following the procedures in the WCAP and the standard methods discussed. Plant-specific evaluations are expected to be able to demonstrate adequate long-term core cooling in the presence of post-LOCA debris.

The owners' group will provide a guidance document to licensees on implementation of the WCAP. The licensees will be provided with the LOCADM code and instructions on needed input and sample calculations, and it is the position of the staff that personnel performing these analyses should receive adequate training and qualification prior to performing the analyses.

Acceptance criteria we've been over. Conditions and limitations. Licensees must perform -- must demonstrate applicability of previous sump strainer tests or perform plant-specific tests. Plant-specific evaluations should verify the applicability of the WCAP blockage conclusions.

If credit is taken for the alternative flow paths, such as the core evapo-plate holes which we've already discussed a number of times, it shall be demonstrated that the paths would be effective and not become blocked.

Licensees shall show that core inlet

blockage will not invalidate existing post-LOCA boric acid dilution analysis. WCAP should be revised to include discussion of fuel swelling and blockage and the assumed flagging oxidation limit of 17 percent shall be used with LOCADM.

DR. WALLIS: Can I ask you while I'm thinking about this now? In the 49, you say, "Plant-specific evaluations should verify the applicability of the WCAP blockage conclusions."

Now I think we were arguing or asking you today if some of those conclusions were not based on very qualitative arguments. Do you expect the plant-specific evaluations to be more quantitative than these qualitative arguments we heard today?

MR. SCOTT: Can I speak to that, Ralph? I call your attention to Page 8 of the staff's safety evaluation. I'll read you a paragraph here.

"The PWR owners' group stated in Reference 3" and Reference 3 is their answers to RAIs, "that a bounding head loss based on tests performed assuming collection of 21.7 cubic feet of fibrous debris and 1,389 pounds mass of particulate debris at the entrance to the core would be expected to be about 10.2 inches of water or an increase in pressure drop of 0.37 psi at the core inlet.

The staff did not review the test results in detail but believes them to be reasonable because of the observation of little debris capture on the fuel inlet grid."

DR. WALLIS: These are the CDI tests that you didn't --

MR. SCOTT: Yes.

DR. WALLIS: -- accept?

MR. SCOTT: We did not accept as standalone evidence.

"It was further noted that the WCAP-16793, Appendix B, W/COBRA TRAC bounding analysis with an assumed flow blockage of 99.4 percent demonstrated adequate flow rate to remove decay heat. A flow blockage of 99.4 percent would result in a head loss substantially greater than 10.2 inches of water. Thus, a plant with a calculated head loss of 10.2 inches of water would be bounded by the WCAP-16793 results and would be able to conclude it would have adequate core cooling."

DR. WALLIS: So, what you're asking them to do is the type of blockage calculation that Westinghouse did with the 99.4 where they assumed everything's blocked and there's one channel not blocked? Is that the kind of thing you want them to verify? What are you really asking them to verify?

MR. SCOTT: That they do not have -- let's see -- a calculated head loss -- that their calculated head loss would be 10.2 inches or less.

DR. WALLIS: You're asking them to verify something that CDI did that you don't already -- we don't accept? You're asking them to verify -- to do another experiment like that or something?

MR. SCOTT: No. It's an analysis.

DR. WALLIS: Well, I'm uncertain what it is you're really asking these plant-specific evaluations to do because it's not really quite clear what these conclusions are based on in some cases. Are you asking them to do more experiments?

DR. LANDRY: We are asking the owners of the plants to perform plant-specific evaluations and those evaluations have to show that they can tolerate the blockages and the conditions --

DR. WALLIS: You are expecting them to do the experiments with --

DR. LANDRY: -- that arise during the course of development of this WCAP and the responses to the standalone --

DR. WALLIS: You are expecting them to do experiments on whether or not a bed can form across the whole base of the -- the sort of questions the ACRS asked you today.

Are you asking them to answer some of those type of questions? Each plant?

MR. SCOTT: No, that's not what we're asking, and again this is described in this paragraph.

Now the rationale that we talked about for why the -- a test of the sort that was done at CDI is not needed for each plant --

DR. WALLIS: Is based on this 99.4 thing?

MR. SCOTT: It's based on -- again, it's a holistic evaluation of both the experimental evidence which was limited as well as the analytical evidence --

DR. WALLIS: I guess I don't --

MR. SCOTT: -- Ralph talked about.

DR. WALLIS: I guess I don't -- I guess if I were a judge, I'd be a little puzzled by what you meant by holistic evaluation. I would like to see a logical derivation of conclusions but let's leave it.

CHAIRMAN BANERJEE: Are you essentially asking each licensee to do or repeat the COBRA TRAC calculation, assuming that one bundle is open and the rest of the core is blocked? Is that what you're asking?

MR. SCOTT: It certainly doesn't specify that here. I, quite honestly, will have to defer to Ralph. Did you have something to add to that?

DR. LANDRY: No, we're asking each licensee to analyze the conditions for their plant, they're required to do this anyway, and verify that their plant does not violate any of the conditions assumed in the WCAP or if they do, they have to reanalyze.

DR. WALLIS: So suppose they did a test and they found they got 10 cubic feet per thousand square feet?

DR. LANDRY: Then that's what they're going to use for their test.

DR. WALLIS: Then they have to do another test like the CDI to show that that's not going to be a problem or what are they supposed to do? It's open-ended. It's very open-ended.

DR. LANDRY: It is open-ended.

MR. SCOTT: I get -- what you're asking, as I understand it, is what kind of analysis are we expecting because clearly this is -- what's being sought here is an analysis.

DR. WALLIS: Well, I would be a bit concerned about plant-specific evaluations showing that WCAP blockage conclusions were wrong.

MR. SCOTT: All right. In that case, --

DR. WALLIS: Then if you did it for one plant, what do you for other plants?

MR. SCOTT: That plant is outside -- in other words, if they have more material and it results in a higher head loss than is shown in the WCAP, then they're on their own, so to speak. They have to do an analysis or potentially a test to show whether it's okay.

CHAIRMAN BANERJEE: So, this WCAP 10.2 inches of water doesn't include any chemical effects, right?

DR. LANDRY: Right.

MR. SCOTT: It sounds like it.

CHAIRMAN BANERJEE: That's true. So, if there are significant chemical effects that would be more than that, right?

DR. LANDRY: And each licensee must analyze their specific chemical effects and species.

CHAIRMAN BANERJEE: So, how would they analyze these chemical effects? Do you give them guidance on how to do that?

MR. KLEIN: I think you have an example how one licensee did that. They used their fiber bypass. They added precipitate and they measured head loss in a CDI-type test. I'm not sure how each licensee will handle that. I'd be surprised if each one runs a test. They may find in many cases that their particular plant's bounded by other tests that have been done.

MR. SCOTT: Let me insert here that this draft set of conditions and limitations in the Draft SE has been provided to the owners' groups. So, standby owners' group, you're about to be on the spot.

You all have, I believe, indicated you do not have concerns with these conditions and limitations which means that you believe that they can be applied. How do you believe they are being applied?

DR. WALLIS: Well, I think it's very difficult because a plant could say, oh, we're going to look at the ANL tests or we're going to use that and then they'd be in real trouble. So, they really may have to do their own tests every time.

CHAIRMAN BANERJEE: Well, that's why I was asking if there's some guidance as to how they might --

DR. WALLIS: What's acceptable.

CHAIRMAN BANERJEE: Yes, what would be

acceptable, either in terms of their own tests or tests that they could refer to which would be considered acceptable.

MR. SCOTT: I am trying to get input from the users here, if they're willing to give it, as to how they would use this. If you could just bear with me one minute.

CHAIRMAN BANERJEE: Let them speak, yes. Mo?

MR. DINGLER: I guess there is a couple ways to do that. One, the plants look at the debris that you got there and compare the two and we're under what's there. See, that's the easy approach.

CHAIRMAN BANERJEE: I missed that.

MR. DINGLER: In other words, they look at the debris loadings that they had in the WCAP and what was tested and they're below those levels, that's a very easy evaluation.

CHAIRMAN BANERJEE: But it says nothing about chemical effects, right?

MR. DINGLER: I understand. I mean, let me answer separate questions at this point.

The other one is, is look at the debris. If the debris is slightly out, the SE allows the use, the correlation of 62.24. So, there's some thought going on and we're still discussing that as an implementation guide to correlate the testing that was done and presented at the WCAP of 10.2 inches, I believe that's what it was, correlate that to the 62.24 correlation and then use those correlations to show are they under those correlations. That's the approach we're looking at at this point. We haven't decided on that yet because one of the conditions is we provide an implementation guide to show how to implement this.

The other one is, as Paul said on the chemical approach, is we believe -- now there's a couple ways to look at it. For rod crud build-up or evaporation of the rod, we assumed everything would get in there and everything deposits.

For head loss in that, we don't believe at these temperatures you're going to see the effects from the testing that was done by the industry and by the NRC in confirmatory testing at these temperatures you will see those type of chemical head losses that you have and won't form on a bed.

CHAIRMAN BANERJEE: Well, so why do you have to do that for the screens?

MR. DINGLER: Because I believe the screens, you'll see that because -- well, there's some screen vendor testing that's doing elevated temperatures. As Paul says, one overseas is doing it based on head loss, actual curves, pH temperature curves and that, and they're seeing quite a bit less debris being generated.

CHAIRMAN BANERJEE: But is their conditions at the core inlet different from the screens?

MR. DINGLER: You'll have slightly different temperatures and stuff like that.

CHAIRMAN BANERJEE: How much difference?

MR. DINGLER: I can't say off the top of my head.

CHAIRMAN BANERJEE: I would have thought they would be negligibly different.

MR. ANDREYCHEK: That's not necessarily true because you will have the RHR flow, the recirculating flow go through a heat exchanger somewhere between the sump and injection into the reactor vessel.

CHAIRMAN BANERJEE: So, it will make it cooler or warmer?

MR. ANDREYCHEK: It will make it cooler.

CHAIRMAN BANERJEE: Okay. So, the screens will actually see more favorable conditions than the core inlet?

MR. ANDREYCHEK: I'm not sure I understand the use of the word "favorable."

CHAIRMAN BANERJEE: In the sense that it will be cooler at the core inlet than at the screens then, if what you're saying is true. I'm only taking your word for it.

MR. ANDREYCHEK: Okay. So, I'm not sure how that makes it favorable at the screens compared --

CHAIRMAN BANERJEE: Because if it's cooler at the core inlet than at the screens, if high temperature makes things better for you chemically, your argument, then it's going to be better at the screens than at the core inlet.

DR. LITMAN: You mean that more of the material precipitates at the screens? Is that what --

CHAIRMAN BANERJEE: I am just saying that why is the core inlet to be treated differently from the screens? It's the same thing. It's the screen with a small surface area, I mean flow area. That's all it is.

MR. KLEIN: I think part of the difference is the -- you have a filter upstream of the core.

CHAIRMAN BANERJEE: I realize that.

MR. KLEIN: So, I mean, you have a debris bed that's -- assuming that you form precipitate and the bulk containment fluid has filtered out a lot of that material and the issue then becomes head loss across the sump strainer.

CHAIRMAN BANERJEE: Well, the way I see it, you've got two screens in the series, one with 10 to 50 times the surface area of the other, and you're delivering stuff at some rate to the first screen. Some of it is being taken out as it's being covered, some of it is passing through. Okay.

This paints, seems to me, a rather coupled calculation. If I was doing it myself, this is the way I would do it. I would look at this as sort of an extension of the screen which is in a series. It's a second screen. I mean, I think you can work out a methodology, but this doesn't seem to be the way to do it, at least at first cut. That's how I would look at it. You put a bigger screen upstream and then you have a smaller screen. They have roughly the same holes in them in terms of size.

Am I getting something wrong? The conditions might be a little different at the second screen because it's colder, so actually chemical effects would be accentuated rather than depressed. So, we should actually look at chemical effects rather more seriously at the second screen than the first one.

MR. KLEIN: I think part -- I agree you have two in series. Part of the analysis would have to be the formation of debris bed on the first screen relative to the time that chemical precipitates might form within the containment fluid, though.

CHAIRMAN BANERJEE: It's a time-varying problem. You need to write a little code or something. It doesn't sound like an incredibly difficult job to do, but presumably you could do a parameter sort of code which takes into account the time at which the stuff comes out, when it starts to precipitate. We don't need really anything very sophisticated, just based on the data, I would think, but it's an interactive process.

What you're trying to do is you're going to separate this and you're going to argue, well, stuff is going to get taken out and then it's going to not arrive at the second one, but it's all varying with time as you cover the screen, stuff is coming through. It's getting caught at the other screen and I just feel that it's a very complex interaction.

MEMBER MAYNARD: What's the second screen you're talking about?

CHAIRMAN BANERJEE: It's the core inlet.

MEMBER MAYNARD: Okay. The core, the holes in the core are going to be quite a bit larger than the holes in the screen.

CHAIRMAN BANERJEE: Well, that's not what they've told us. Now, if they say that this core inlet is 20 times the size of the other screen, I'd be quite happy for that.

MR. DINGLER: I think there was a misunderstanding that Tim said when we first started this morning, this noon, that the openings in the bottom were quite a bit larger than the sump screens and it was misunderstood when he first said it because he was looking at something else, not the bottoms.

CHAIRMAN BANERJEE: So, what are the hole sizes at the inlet of the core, at the various grid spacers, and all this stuff because I keep asking this question, what is the geometry and what is the hole size? If it's not the inlet, then it's at the next level or wherever.

MR. DINGLER: I will say for one plant, the openings in the fuel is greater than an eighth of an inch to a quarter of an inch. They're greater than that because that's what our sump -- the sump screen was when we replaced, was the -- the sump screen had a smaller opening than the fuel did, and we had a quarter of an inch opening in our sump screens.

CHAIRMAN BANERJEE: Okay. I think what we need is some quantitative information here which is typical of, say, whatever. As this is supposed to be generic, this report, let's have a generic information as to what is the generic upstream screen, what is the generic core inlet screen, and what is the generic fuel screen, I'm going to call them all screens because that's what they effectively are, hole sizes?

That at least will clarify it somewhat because otherwise these arguments are very qualitative. Stuff is going to go through early, then it's going to go through late and there's chemical effects which are going to be taken out there and going to go back there. I mean, there's nothing very quantitative here.

MR. KLEIN: Well, just to be clear, the one licensee approach that I described earlier assumed that all chemical precipitate was carried to the inlet, to the core and they measured the head loss in the CDI test with fiber and then with a 100 percent chemical load of WCAP surrogate that we know is capable of producing high head loss.

CHAIRMAN BANERJEE: And how much was the

flow velocity through that screen?

MR. KLEIN: That is the question we still need to get back to you on.

CHAIRMAN BANERJEE: If they got it more than three centimeters a second or whatever it is, give them a gold star and that would be okay.

But also, the head has to be representative, of course, of what is available.

DR. LITMAN: I think there's one other thing that I want to address and that's the temperature differential that you're talking about between the first screen and the second screen, the first screen being the sump screen and the second screen being the fuel debris catch on the bottom.

The heat source in this whole merry-go-round is the reactor core. That's the hottest spot in the place.

CHAIRMAN BANERJEE: That's downstream.

DR. LITMAN: Well, that's the bottom of the fuel. It's going to be pretty hot. It's going to be a lot hotter than the inlet to the screen to the sump because you have latent heat on the -- excuse me?

DR. WALLIS: Water comes from the sump and goes to the core.

DR. LITMAN: Excuse me. Excuse me. The

latent heat from the metal in the reactor vessel and the fuel latent heat is going to have a tremendous effect on the debris bed on the bottom of the core in terms of hotness.

CHAIRMAN BANERJEE: Latent heat?

DR. LITMAN: The latent heat from the metal is tremendous.

CHAIRMAN BANERJEE: The stored heat is gone.

DR. LITMAN: Well, it's not, it's not gone within a day.

CHAIRMAN BANERJEE: Not from the vessel?

DR. LITMAN: Oh, no.

MEMBER ABDEL-KHALIK: Isn't there a heat exchanger between the pump outlet?

DR. LITMAN: Yes, there is. There's an RHR heat exchanger that does cool the water down.

CHAIRMAN BANERJEE: We need some quantitative numbers. I mean, this is again hand-waving. If you're going to appeal to the increase in temperature, we need some numbers which shows what that is.

DR. LITMAN: I understand your concern.

DR. WALLIS: I would think the water's colder when it gets to the core. It's been through the RHR and hasn't seen much of a heat transfer surface till it gets to the core.

MEMBER MAYNARD: Well, the first point -- I mean, the first 20 hours which is not covered in this, but the first 20 hours you're getting basically cold water injection from your RWST and so it's been about 20 hours or more when you switch over to recirc.

DR. LITMAN: 20 minutes.

MEMBER MAYNARD: 20 minutes. Okay. So.

CHAIRMAN BANERJEE: Well, let's have some numbers.

DR. LANDRY: In that period of time, you're not going to take, as Bob was just pointing out, a huge amount of energy out of a nine-inch thick steel wall, a core barrel, coming down into a lower plenum which is six-to-nine-inch thick steel. You're talking about removing an incredible amount of energy.

DR. WALLIS: What's the transient time for that to come out?

DR. LANDRY: It's a heck of a lot --

DR. WALLIS: It's steel. It happens pretty quickly.

DR. LANDRY: It's sitting at 585 degrees when you start.

DR. WALLIS: Yes.

DR. LANDRY: And it's going to go hotter during the accident and now you're going to recirc the water into it.

DR. WALLIS: It's going to cool down.

DR. LANDRY: That darn stuff is going to be hot.

CHAIRMAN BANERJEE: Ralph, I don't argue. I think we just need to know the temperature of the water coming into the core inlet.

DR. LITMAN: And I think it's an important point, but just as a point of reference, when we do refueling outages at the nuclear plants and you want to cool down a steam generator so that you can go in and do your current testing, the only way to do that after the plant has been shut down for five days to bring the temperature below a 140 degrees of the water that's in there is to refill the generator two or three times with cold water in order to bring the temperature down.

The latent heat and the size of that vessel and the size of the reactor vessel --

CHAIRMAN BANERJEE: The stored heat?

DR. LITMAN: It's pretty -- the stored heat in the metal is tremendous.

CHAIRMAN BANERJEE: We need to have --

DR. LITMAN: I understand the question.

CHAIRMAN BANERJEE: I think there are two separate issues here. One is if there's going to be appeals made to the raised temperature, then we need quantitative numbers. Sorry. If there is going to be an appeal made to the increased temperature at the inlet of the core where this stuff accumulates, then we need to have a quantitative idea of what that is, and the second thing is that indeed that this does have an effect which is so significant on the chemical processes that go on and there has to be sort of a clear guidance then given as to how this should be taken account of.

If I was a licensee and I was going forward with this, I would need to know how to calculate that temperature, how much credit to take for it, and what tests to appeal to then to say that this is not going to be important or going to be important or how important.

DR. WALLIS: What time period are we talking about here? We're talking about 20 minutes after LOCA or something? We're told in the different contexts all together that the concrete which was something, you know, several feet thick comes to equilibrium in an hour and you're telling me that steel which is only 10 inches thick doesn't come to equilibrium in 20 minutes?

CHAIRMAN BANERJEE: They're going to clarify this.

DR. WALLIS: There's something odd.

CHAIRMAN BANERJEE: Graham, I don't think we should pursue this further. We're just going to take time trying to do that.

DR. WALLIS: Every time you bring up a qualitative argument, it makes me more suspicious.

DR. LANDRY: The concrete wasn't anywhere near 585 degrees Fahrenheit.

CHAIRMAN BANERJEE: Let's -- Ralph, I think we can answer this very easily, quantitatively. You get it out of TRACE or whatever. I mean, you've got your -- so, you've got the numbers. You know what the core inlet temperatures are going to be for the liquid coming in. So, it's not a big deal.

MR. SCOTT: We need to discuss each of these conditions and limitations. I think we've been over most of them, haven't we, Ralph?

DR. LANDRY: We've covered all of these during the discussion already today.

CHAIRMAN BANERJEE: Are there any very important ones, Ralph?

DR. LANDRY: Well, they're all important.

CHAIRMAN BANERJEE: Yes, but one --

DR. LANDRY: We've already --

CHAIRMAN BANERJEE: -- that needs attention now?

DR. LANDRY: No. We've discussed all of them already today in the course of the discussions.

The conclusion of the staff is that the application of the procedures and methods described in the WCAP will provide an acceptable plant-specific evaluation of the plant's ability to adequately remove long-term decay heat from the core following a postulated loss of coolant accident.

DR. WALLIS: Well, wait a minute. There are no methods described in WCAP for saying where the debris goes and what its effect is. There are no methods at all in there. It's all qualitative. So, I don't know what methods you're talking about as far as where the debris goes and what it does.

You're talking about the 99.4, so the very interesting and very good calculation. That still doesn't say where the debris goes and what it does. There's no method here that describes what the debris does.

DR. LANDRY: There are a lot of methods.

There are methods.

DR. WALLIS: No, there's no methods in this WCAP for that, is there? I mean, I don't see any --

CHAIRMAN BANERJEE: I guess what the WCAP does is it takes a number of scenarios which may or may not be typical but let's say they are somewhat typical of the situation and provides an evaluation of those scenarios.

So, if you are living within the scenario, then perhaps you've got something to lean on there and you can reference it and say, look, I live within this scenario, I reference it, if we accept the WCAP as it stands, of course.

MR. SCOTT: There are criteria in the WCAP and referred to in the SE. There are descriptions of actions that can be taken to show that the plants are within those boundaries.

Now, in some cases, as was pointed out, there's not a lot of detail in what we're saying as to how this could be met. The paragraph that I read you is an example of a criterion and it doesn't have a lot of detail, as you point out, and okay, well, how do you get to whether you meet that criterion or not?

So, we understand that point. I don't

think it would be accurate to say there are no criteria or methods in this.

CHAIRMAN BANERJEE: So, when I say scenario, it does include a set of assumptions, set of criteria, whatever. So, you've sort of bounded a situation, done some analysis for that and shown that it might be acceptable within these sets of assumptions, not you, the licensee -- I mean the owners' group have.

MR. SCOTT: Right.

CHAIRMAN BANERJEE: And you've examined that and you've said, okay, subject to these limitations and conditions, you can proceed, but I guess Graham's point, and I don't want to paraphrase him, is that these scenarios are fairly limiting and have a number of assumptions there.

What happens if you don't meet all those assumptions? There's no methodology set out for how to do that.

MR. SCOTT: That's generally true, I believe. As with any regulatory document that's not a regulation, if you fall outside the boundary -- you know, the regulatory document provides a tool for getting to an endpoint, for a plant that can fall within or chooses to fall within the boundaries posed by the regulatory document, for example a reg guide, and if you fall outside that boundary, then you can use another approach and you're burdened with showing that your approach is adequate and that's going to be the case for a plant that doesn't fall within these criteria and the conditions and limitations and you may say, well, you know, you've left them a lot of stuff yet to do and I'm sure that's true.

One thing we did do, as I mentioned a few minutes ago, was provide these conditions and limitations to -- through the owners' group to the users to see if they're usable as is or whether there are issues.

DR. WALLIS: Let me tell you specifically what is my concern here, is that in Section 2, there are a lot of assertions about the fibers and what they do and they won't block the core and so on and so on. So, you then look for the chapter where there's some analysis of what the fibers do and there isn't any. The only thing you have is Chapter 6 which is this very good and very nice evaluation of the 99.4, so on, but that doesn't tell you what the fibers do. It doesn't tell you how to calculate anything about what they do and that, seems to me, is something that's missing from the WCAP.

MR. SCOTT: What exactly do you mean by what the fibers do?

DR. WALLIS: Yes.

MR. SCOTT: Give me an example, please, to help me understand.

DR. WALLIS: In Section 2, there's all kinds of stuff about the fibers won't block the bottom of the core and they'll go through here and they'll do this. All these assertions are made in Chapter 2.

MR. SCOTT: Okay.

DR. WALLIS: There's no method in the rest of the document that supports those assertions.

MR. SCOTT: Okay. I'm not familiar enough with Chapter 2 --

DR. WALLIS: Maybe there is but I can't find it.

MR. SCOTT: Okay. I'm not familiar enough with Chapter 2.

DR. LANDRY: You need to read the RAIs and the RAI responses.

DR. WALLIS: They have never been given to us.

MR. SCOTT: I think now they have been given to you, is that correct, Ralph? Didn't we put them on the computer?

DR. LANDRY: On your computer.

MR. SCOTT: You now have them, yes. We did not provide them to you before, we have now provided them to you.

DR. WALLIS: And so they will be incorporated in a modified WCAP, so that they then define a method which can be used?

DR. LANDRY: The revisions to the WCAP, like any topical report, incorporates the responses to requests for additional information.

CHAIRMAN BANERJEE: We -- I think we're at the point where we can have some further discussion and then give our views.

MR. SCOTT: May I sum up our view on summarizing, if we could?

CHAIRMAN BANERJEE: Sure.

MR. SCOTT: First of all, I'd like to go over the items that I took as action items of a sort. A couple of your questions, I think we answered subsequently when we brought staff in. We committed to you to provide the RAIs and the RAI responses. We've done that.

I believe you have a question for the owners' group on what flow would result in a core level less than one-half. I believe that's out there for them to answer, correct?

CHAIRMAN BANERJEE: I can make it even more precise.

MR. SCOTT: Okay.

CHAIRMAN BANERJEE: I see the graph that they gave which is Number 33 or whatever. Let me see where that is.

MR. SCOTT: Slide 33?

CHAIRMAN BANERJEE: Yes. I'm not sure that -- no, sorry. It's the one where they show the levels and things. Where is it? I had it before. It's after the TRAC or the -- okay. It's 43. Sorry.

Let's put this question precisely. What would be the resistance of the inlet of the core to -- in terms of even inches of water or whatever it is, decay, so that you got an integrated mass flow below the green line in that graph?

MR. SCOTT: Resistance at the core inlet that would lead to flow below the green line?

CHAIRMAN BANERJEE: Yes. You can do it whichever way you like, but I'd, of course, like to be able to compare it with the pressure drop across a screen. So, it would be nice if they gave it to me in terms that I could compare with data taken with screens.

MR. SCOTT: Okay. You all understand that request? No problem, right? Okay.

We had a concern about the basis for conclusions regarding formation of uniform bed at the core inlet. We gave you the answer that we have now. We will go back and consider your comment and see if we have additional answer to make to that.

You raised a question --

DR. WALLIS: You've got the -- how would you calculate the pressure drop across the --

MR. SCOTT: Say again.

DR. WALLIS: To feed into -- you know, you were saying, you know, this green line and all that. Well, that means there's a certain pressure drop.

Now if you got this bed across the core, how would you calculate that pressure drop? You're saying you're going to investigate the conditions for it to form. Once you've got it, how would you calculate the pressure drop through it?

CHAIRMAN BANERJEE: It's part of my --

MR. SCOTT: If, you know, by logical extension here, if we were to conclude that an objective of this test is to show that such a bed would not form and then we end up finding that it would form, we would find ourselves in a situation where we would have to test, I believe, if that's where we went with that.

What we're saying now is we do not believe that kind of bed would form.

DR. WALLIS: Ever?

MR. SCOTT: Based on the conditions specified in the WCAP.

DR. WALLIS: Is that based on the one cubic foot per thousand foot square?

MR. SCOTT: Again please check Page 8 of the SE. It has numbers.

So, we do not believe, based on what the information that's available now, that that sort of thing would happen with --

DR. WALLIS: Well, I've heard this before. I hate to bring this up, but when the ACRS raised the question about are there chemical effects, people said we do not believe there are chemical effects. We've heard this we do not believe so many times before.

MR. SCOTT: Yes, you're absolutely right. GSI-191 has been full of surprises. So, I would like to consider your comment and discuss it with you all again. Okay?

There was -- a concern was raised regarding boric acid mixing in the presence of debris and we will undertake to get you an answer on that.

You requested a copy of -- and this is Paul's item -- a copy of a paper on heat exchanger fouling and cleaning, right? Is that Paul's or is that somebody else? Yes, Paul. So, Paul will provide you that paper. He will provide it to David who then, of course, can send it on to you.

An item was raised regarding an acceptance -- the acceptance criterion of the SE does not address chemicals and what are we going to do about that, and then there was the related concern about the temperature differential which may be higher in the vessel, lower in the vessel, and how does that sort out. So, we're going to get you an answer to that.

And I believe that the owners' group has a look-up to get back to you on core hole sizes because there was some thought they were smaller than the strainers and then that they're larger than the strainers. So, they owe you an answer on that.

CHAIRMAN BANERJEE: And not just going in but at the various levels. I mean, --

MR. SCOTT: In other words, you're asking what the clearances are at the spaces.

CHAIRMAN BANERJEE: Wherever they are.

MR. DINGLER: We'll send that to Mike.

Some of that may be proprietary. So, we'll have to work our way through some of that.

CHAIRMAN BANERJEE: That's all right.

MEMBER MAYNARD: I think you could at least provide a typical one. There are typical grid structures and typical bottom-mounted debris nozzles.

MR. DINGLER: If you can find a way -- hopefully we can get by with typical, if it's all right with everybody, that gives us a little more --

MEMBER MAYNARD: You can provide proprietary at some point to get down to some of the specifics, depending on --

MR. SCOTT: The committee, I believe, would prefer to not receive proprietary information, based on my recollection of how it goes, yes. Okay. So, they understand this, right?

CHAIRMAN BANERJEE: We can receive but we prefer not to receive.

MR. SCOTT: Right.

MR. DINGLER: The reason is I got two fuel vendors that love each other, so.

MR. SCOTT: So, they understand the situation. They will attempt to provide.

CHAIRMAN BANERJEE: The fuel is very similar, isn't it?

MR. DINGLER: I can't comment because they won't share that with me.

MR. SCOTT: Okay. So, those are the items that I noted that we plan to address in some manner between now and the full committee meeting in April and then, as I mentioned at the beginning of this, we would ask that at the conclusion of that meeting you consider writing a letter on this subject.

Based on today's discussions, I suspect you're going to say that additional testing would be appropriate. We understand that because from the beginning of GSI-191, there have been many uncertainties. We have addressed a number of them and many remain and so it is quite possible that your recommendation would include something like that and so what really is a question before us here --

CHAIRMAN BANERJEE: You may have the additional tests already, as far as we know.

MR. SCOTT: Well, we don't have extensive testing beyond what's been discussed today. I mean, I'm not trying to presuppose our answers to your questions that you posed today.

CHAIRMAN BANERJEE: Right.

MR. SCOTT: But I don't think we're going to have a battery of tests to come in with on some of these items or else we would have done it today. Okay. So, I suspect that what we're -- that you're going to still find that perhaps additional testing is needed to be confirmatory.

Then the question is do we have enough information, as the staff has concluded we do, to support closure of this issue, even in the presence of remaining uncertainties, because there will always be uncertainties, and so the task, as we see it, before you all is to, from your perspective, sort out where we stand on that, given the additional information that we'll provide you in the RAIs and the RAI responses and the answers to your questions here.

And I think that's --

CHAIRMAN BANERJEE: Let me ask you a question, Mike.

MR. SCOTT: Okay.

CHAIRMAN BANERJEE: If there is some modest amount of confirmatory or additional testing required, it could well be that you have this data because of some of your licensees doing some of the testing.

MR. SCOTT: Could be.

CHAIRMAN BANERJEE: I've heard about some of this already. You've referred to them qualitatively.

What sort of time scales are we talking about? Is it a few months, two or three months?

MR. SCOTT: Well, it depends on the complexity.

First of all, it depends on whether we're talking about analyses or tests and clearly analyses can be done in general quicker than tests can be done that involve, you know, -- typically for us, we've got to find budget for the tests and we have to find a contractor and get the contract let and the tests constructed and the tests run which is the very same thing that each of the licensees is going through now to try to get their strainers done and they've been working on that for two years, at least. A couple years.

CHAIRMAN BANERJEE: Well, the reason I ask this question is that you've referred to some tests done by the licensees which might have a bearing on this issue and I don't know what. You can certainly divulge the information to us in the sense that everything we do can be proprietary. There's not an issue there, except we prefer not to be in that space.

MR. SCOTT: Well, most of the licensee testing, as described to us, has not been proprietary.

Quite honestly, some vendors are more sensitive to that sort of thing than others.

CHAIRMAN BANERJEE: Well, if it is not proprietary, is there any issue in letting us include our judgment on just looking at these tests which might be appropriate? You referred to some already.

MR. SCOTT: We have no objection to you all (a) having the information that we have and (b) I mean if you want to witness tests, that's fine. I mean that's your prerogative.

It has been very difficult. We have been trying for six months to visit one of these facilities. We originally were slated to go to it in October of last year. We still haven't been because it keeps sliding out as issues emerge and are addressed, many issues of which were raised by us.

So, it's not trivially easy to catch these tests but we can certainly attempt to work with the vendors, if you would like to observe a test. Now, the strainer head loss tests, understand, is the same sort of tests that were described to you in May of last year.

CHAIRMAN BANERJEE: And you say one licensee is actually taking it to the point where they've looked at the head losses in the core itself, right?

MR. SCOTT: This is what you all were talking about, Paul, a few minutes ago. So, we could certainly give you that licensee's name and we could --

CHAIRMAN BANERJEE: Well, you could ask them if we could see the --

MR. SCOTT: Well, if you could see the results. Of course you could see the results because we could ask for the results and the results, at some level, have presumably already been provided to us. So, we can certainly share that with you.

CHAIRMAN BANERJEE: They had chemical effects, didn't they, as I understand it, correct?

MR. SCOTT: Yes, okay. So, this is one plant that did actually an in-vessel test on their own that we know of, right?

MR. KLEIN: That is correct, and the information I provided was in their GL supplement. I suspect the level of detail that they might be interested in is beyond what was provided in that GL supplement.

MR. SCOTT: Okay. So, we have already GL supplement from this plant. I assume it's non-proprietary, most of them are, so we can send you the

Adam's number for that, if that would be useful.

But what Paul's saying is given the details of the questions you've asked today, you may or may not find that satisfying in which case we could ask them for more data or other information they might have.

CHAIRMAN BANERJEE: Let's take a look at it anyway.

MR. SCOTT: Okay. Let me just write that down. The owners' group probably doesn't have further information on that plant's test, do you?

MR. DINGLER: No, we don't.

MR. SCOTT: No, you don't. Okay. Too bad.

CHAIRMAN BANERJEE: The only information you have on the tests that are in your report right now.

MR. SCOTT: Okay. I understand that we have 5,000 pages of documentation and that we haven't been through yet. We've had them for two weeks. So, there may be stuff in there that we simply haven't gotten to yet and it will be some time before we do, but --

CHAIRMAN BANERJEE: Well, you know, it may answer some of the questions. I don't know procedurally what that means exactly, but, I mean, there's reality and then there's sort of what we have to do above this report and in reality, if there's no issue, it makes us feel much better.

MR. SCOTT: Of course.

CHAIRMAN BANERJEE: You know, and that's really where we're going. If you've got data and things that suggest that this is not a big problem, that would be really nice.

MR. SCOTT: Okay. And you've seen some of that data that has put us in the position we're in, but I hear you saying that you're not fully convinced and would like more.

CHAIRMAN BANERJEE: Well, I'm just speaking right now not for the committee obviously. I mean, the committee may have a different viewpoint and the full ACRS Committee may have a different viewpoint, also.

So, I just think personally at the moment it would be nice to see some more data, but I have to look at what you've already got in that GL and stuff, take a look at that.

MR. SCOTT: Okay. We'll get you that information and we'll find out if there's other information of this sort out there that we could send to you.

CHAIRMAN BANERJEE: I don't know. Maybe Said needs to say something.

MEMBER ABDEL-KHALIK: Well, I have a few --

MR. SCOTT: Before you do, can -- was this a question for my wrap-up?

MEMBER ABDEL-KHALIK: No, no.

MR. SCOTT: Can we let my boss wrap-up, too?

CHAIRMAN BANERJEE: Okay.

MR. RULAND: Yes, Bill Ruland again. Is the mike on? Okay.

Mike, I'm just wondering, given the number of items and I'll ask Sanjoy this also, given the number of items, do we think we're going to have these things supplied and have the committee have sufficient enough time to review this, the subcommittee, before the full committee? Do you think it's possible?

MR. SCOTT: Maybe not. The full committee meeting is the first week in April.

CHAIRMAN BANERJEE: It's the second week. It's the 10th and 11th.

MR. SCOTT: Second week in April. So, you would certainly not have much time to look at it before the full committee meeting.

MR. RULAND: Right. That's my question.

MR. SCOTT: So, I guess it's kind of do we postpone the full committee?

MR. RULAND: I'm just raising the question.

CHAIRMAN BANERJEE: Sounds like a good question.

MR. RULAND: Sounds like you had 10 -- there was 10 -- like 10 items on your list there and a number of the things, I think the staff has to think about, right?

MR. SCOTT: Several of them, yes.

MR. RULAND: And that's probably a week's time, I suspect.

MR. SCOTT: At least.

MR. RULAND: And then get back to the committee and before you know it, it's next month. So, I mean, believe me, I'm not advocating, you know, delaying GSI-191 one iota more than necessary, but it just struck me that this is a lot of work. That's all.

MR. SCOTT: Do I recall correctly the committee doesn't meet in May?

CHAIRMAN BANERJEE: It meets.

MR. SCOTT: It does meet in May.

CHAIRMAN BANERJEE: It doesn't --

MR. SCOTT: It doesn't meet in August.

CHAIRMAN BANERJEE: The problem we have, of course, with some of us is that we are also very involved with Hope Creek and we really need to deal with that at the full committee meeting. So, I don't know how many of us will have a great deal of time to look at things as well. We'll give it our best shot obviously.

MR. SCOTT: The issue that Bill Ruland was referring to is, as we mentioned to you, the licensees have extensions to complete certain analyses, among them this one, and if we delay in issuing the final SE, we are likely to see additional extension requests from them. So that's why there is importance to this.

On the other hand, if it's not ready, it's not ready.

MR. RULAND: Do you think, Mike, that we could get maybe answers to these questions and basically give it a turn-around in a week? Do you think that's doable?

MR. SCOTT: I don't know. Not without talking to the staff.

MR. RULAND: Okay.

MR. SCOTT: I think some of them we may say here is an answer. Maybe a more comprehensive answer would take more time.

MR. RULAND: Maybe what we could do is we could get an answer, the best answer that we can provide in one week, regardless. Maybe that's what we do. Would that be acceptable?

CHAIRMAN BANERJEE: I think to begin with. Now, it may be that we -- if we need more information, If we need more information, then it might be simply be that we would have to postpone things.

MR. RULAND: I understand that.

CHAIRMAN BANERJEE: Is it already an agenda item, do you know, in the --

MR. SCOTT: I believe it is.

CHAIRMAN BANERJEE: Okay. So that's in the public record now.

MR. SCOTT: Well, we could change it.

CHAIRMAN BANERJEE: We could change it, yes.

MR. SCOTT: As Bill said, we'll give you an answer to these items in a week and then maybe you all can make the choice whether you want to postpone or not. Would that work?

CHAIRMAN BANERJEE: Yes, I think that's

not a bad approach right now.

MR. SCOTT: And I assume that the owners' group --

CHAIRMAN BANERJEE: Do you want to give guidance to the licensees?

MR. RULAND: Yes, exactly.

CHAIRMAN BANERJEE: I think that becomes an issue.

MR. KRESS: Generally when the agenda items have been notified in the Federal Register notice, we've had much difficulty in changing that.

DR. WALLIS: But we have done it. I remember doing it in the same kind of context as this one. We have done it because I remember doing it when we had something which was not ready. We had to just fill the time with something else.

CHAIRMAN BANERJEE: Let me do this. Let's take an opinion from the other members here who will actually be dealing with this. Mike Corradini has vanished, but we will find him and get his opinion as well.

So, let's start with Graham and Tom. I mean, if we do get, let's say, the best shot they can give in a week to some of these questions, we don't know what's going to be there precisely, but then do we have enough time to consider these matters and --

DR. WALLIS: Well, I was thinking about what I'm going to do in the next couple of weeks and I was wondering if I would have enough time to give a really thoughtful and significant review of what I have in front of me now without having anything new like RAIs and other reports to look at.

I mean, I have enough questions that I have to sort out in my mind about the WCAP as it is now without looking at anything else and what I heard today, I've got to take into consideration, too. I don't want to go and do something superficial. I want to give you some good advice and now I've got to digest something new, I'm not quite sure how I'm going to find the time because there are other things going on in my life.

MR. RULAND: Noted.

MR. SCOTT: We're sorry, but GSI-191 is all there is. There's nothing else.

CHAIRMAN BANERJEE: Since he is the one that has caused a lot of the issues to come up, he has to dispose of them, too. Tom?

MR. KRESS: I actually think a week's time would give you enough time to look at it. I think we could give these questions our best shot in a week's time. That would give us time to look at them and basically I don't -- I agree with Graham. There's a lot to do with the WCAP as it is and the RAIs, but these particular questions, I think we could review them.

CHAIRMAN BANERJEE: We can review them.

MEMBER MAYNARD: I think we should try. I believe that we can. I believe that after that, there may still be an open question or two and we may have to meet on it again, but I'd hate to see us just postpone it and not go ahead and meet in April and at least address as many of them as we can as they have a chance to prepare for us.

CHAIRMAN BANERJEE: Well, we've done this before. We've addressed things partially at a meeting and then closed it down.

MEMBER MAYNARD: We may decide to wait until the May meeting to write a letter. There may have to be, you know, more information or we may be able to take care of it all in the April meeting. I just -- I think we should at least do as much as we can in the April meeting.

CHAIRMAN BANERJEE: Said?

MEMBER ABDEL-KHALIK: I guess without knowing how much information you will provide, it's kind of hard to give you an answer.

MR. RULAND: I understand that.

CHAIRMAN BANERJEE: And you're going to be overwhelmed with Hope Creek, I would imagine.

MR. RULAND: Hope Creek's going to be easy.

DR. WALLIS: We have an ESBWR meeting coming up, too, don't we?

CHAIRMAN BANERJEE: The ESBWR letter is not needed in April.

MEMBER ABDEL-KHALIK: But there may be additional issues that will come up in the summary period beyond what you elicit and those issues, you know, may -- you may agree that they are issues and you may judge that they will take more than a week to resolve.

MR. RULAND: We appreciate that and actually I'd be surprised if there is no additional questions based on the additional information we gave you. I'd be surprised.

But it really is important for us to keep moving forward on this issue and I -- so, I'd appreciate your forbearance to give us the best shot we can do in a week. We will also try for those answers that we cannot provide you to kind of at least lay out what our approach is, if we can do so, and that's really the best we can do.

I'm already asking -- you know, we're going to have to go back and probably delay our schedules in some other areas to -- you know, we're doing -- as a result, we're also doing quick-look reviews during this time. The staff, Mike's folks are really taxed. So, we're going to have to juggle some things, but it really can't be helped, I don't think.

CHAIRMAN BANERJEE: So, the way we leave it is we'll take it up at the full committee meeting in April on the basis of whatever information we get and your presentations, of course, in the full committee meeting should reflect some of these issues.

MR. RULAND: Understand.

CHAIRMAN BANERJEE: As best as they can.

MR. RULAND: And we know that going to the full committee, not having resolved these issues at the subcommittee, involves some risk. We understand that and we're willing to accept that risk at this stage.

CHAIRMAN BANERJEE: Okay.

MR. SCOTT: Did you anticipate hearing from just the staff at the full committee or from the owners' group as well?

MR. DINGLER: Staff only.

MR. SCOTT: I wasn't asking you.

CHAIRMAN BANERJEE: I think how many hours do we have? Two hours? I think a brief presentation by the owners' group would be valuable.

MR. SCOTT: Brief being a relative term with the ACRS?

CHAIRMAN BANERJEE: Well, I can't stop my colleagues from asking questions obviously.

MEMBER MAYNARD: I really think if we only have two hours on the agenda, it's going to be very difficult to have two different groups presenting in that time frame.

CHAIRMAN BANERJEE: Well, it's a question of value added, and it's sort of their report that we're approving. So, I don't know. I mean, my sense of it is that it would be valuable to at least hear from them.

MR. SCOTT: Put it this way. You have -- if you wanted the full committee to hear a presentation from the staff in anything like the detail of this presentation, your two hours is gone.

CHAIRMAN BANERJEE: No, we don't. Obviously not because, as you know, the full committee, I think, will --

MR. SCOTT: Has less time.

CHAIRMAN BANERJEE: Yes, much less time. We need to hit the highlights and as you also know, the full committee's very interested in calculations and experiments and things, you know. Obviously that will catch their interests and convince them that things are okay or not. So, my sense of it would be to keep it fairly focused and discuss eventually the terms and conditions of whatever in some detail but get rapidly to the state why you think this --

MR. RULAND: Maybe the owners' group -- maybe folks can focus on the hard spots, you know, give an overall presentation and then, you know, here was the focus area of the subcommittee and focus on those areas where you had the most interest from the subcommittee. Could you guys do that?

MR. SCOTT: They would be more than pleased to do that.

MR. RULAND: I saw the excitement in their faces.

CHAIRMAN BANERJEE: Why don't we do this, that maybe not -- allocate you 45 minutes but really think of a presentation which is half that time because with the questions, it'll take 45 minutes.

MR. SCOTT: You being them?

CHAIRMAN BANERJEE: Them.

MR. DINGLER: He was looking at us, unfortunately.

CHAIRMAN BANERJEE: Yes, and then the staff we'd give an hour and 15 minutes or something.

MEMBER ABDEL-KHALIK: Would it be appropriate to have a half day subcommittee meeting the same week as the full committee meeting ahead of time so that we can at least get to see the details of the answers that you will provide?

CHAIRMAN BANERJEE: There is an ESBWR meeting on the 9th, unfortunately. I mean, we're really jammed this time. I don't know if there are people who are willing to come in for the afternoon of the 8th, if that's a feasible thing. This is a very good idea, but I was trying to avoid that, if it was possible, really. Of course, that would make going through the full committee meeting much easier.

MEMBER MAYNARD: I think it is going to be very difficult in two hours at the full committee meeting to do much more than kind of give a summary. I don't think you're going to be able to get into very much question and answer, get into some of the things. So.

CHAIRMAN BANERJEE: The 8th is what, a

Monday? No, Tuesday. The 8^{th} is a Tuesday. Tuesday afternoon potentially?

MR. SCOTT: I don't have a schedule. It may be a possibility.

CHAIRMAN BANERJEE: Is it a possibility?

MR. SCOTT: I'll check the schedule.

CHAIRMAN BANERJEE: Yes. What do you think about that half day, Mike? I'm just --

MR. SCOTT: I don't have a major objection to it. I think to try to tailor presentations to two meetings in two days would be a challenge for us. Perhaps if we used the same presentation to talk to the subcommittee and just answer your questions, maybe that would be a little easier to accomplish. You see what I'm saying?

CHAIRMAN BANERJEE: Yes, yes.

MR. SCOTT: Especially since we're talking a short turnaround here.

CHAIRMAN BANERJEE: And you could have some back-up slides.

MR. SCOTT: Depending on how the answer to these questions shake out.

CHAIRMAN BANERJEE: I really am in two minds about this. I don't know what to do because --

MR. SCOTT: Do you have time from a

noticing standpoint? I don't remember.

CHAIRMAN BANERJEE: I don't know.

MEMBER BLEY: Normally it is a 15-day requirement on the Notice of Federal Register.

MR. SCOTT: So, it's nip and tuck. I guess there's time. Yes, there's time.

MEMBER BLEY: Yes. So, it's three weeks from now, roughly.

MR. SCOTT: We can certainly come in and talk to the subcommittee again.

CHAIRMAN BANERJEE: Just half a day, though.

MR. SCOTT: Okay.

CHAIRMAN BANERJEE: Afternoon, maybe.

MR. SCOTT: I mean, we can support that. I assume the owners' group can with pleasure, right?

MR. DINGLER: We'll have to check our schedules on that.

MR. SCOTT: Okay.

CHAIRMAN BANERJEE: It would be sort of a -- it would make the full committee meeting go a lot easier, of course, in some sense to do that.

MR. SCOTT: Okay. So, the afternoon of the 8th, was it?

CHAIRMAN BANERJEE: Right.

MR. SCOTT: Okay.

CHAIRMAN BANERJEE: I don't know how I'm going to do it but we'll figure it out.

DR. WALLIS: You are trying to schedule a new subcommittee meeting now?

CHAIRMAN BANERJEE: Yes. So, we better check. You have -- you're going to be here for the ESBWR, right?

DR. WALLIS: Yes.

CHAIRMAN BANERJEE: Also Tom, are you here? So, the question is instead of coming in on the evening of the 8th, can you come in in the morning of the 8th? Then we do a half day. Is it okay with you, Otto, too? Can you come in in the morning of the 8th?

MEMBER MAYNARD: Yes.

CHAIRMAN BANERJEE: Said?

MEMBER ABDEL-KHALIK: Yes.

CHAIRMAN BANERJEE: Okay. So, we can probably do it. I'll check with Mike, but most of us can do it.

DR. WALLIS: The purpose will be to answer these specific questions which we are -- Mike summarized?

MEMBER ABDEL-KHALIK: And any additional questions that may come up during our own summary at the end of this meeting, if there are any more.

Subcommittee Discussion

CHAIRMAN BANERJEE: Okay. All right. So, let's -- if it's okay now, Bill is done, we can ask the -- we start with Graham. Do you have any comments, suggestions, beyond what we've already --

DR. WALLIS: I thought I'd said too much already.

CHAIRMAN BANERJEE: You never say too much.

DR. WALLIS: I want to consolidate them into something that makes some sort of sense and write it up which is my job as a consultant.

CHAIRMAN BANERJEE: Right.

DR. WALLIS: And this will go to you.

CHAIRMAN BANERJEE: But do we have anything --

DR. WALLIS: And you can do what you like with it.

CHAIRMAN BANERJEE: I remember when I was a consultant and I was writing for you. So that was fun. Anyway, go ahead.

DR. WALLIS: I've learned that the effect of consultants get to be diluted when it gets to the committee.

CHAIRMAN BANERJEE: Right. Do you have any comments beyond what you already said?

DR. WALLIS: No, I think I've said enough. Thank you.

CHAIRMAN BANERJEE: All right. Tom?

MR. KRESS: Well, I have the same problem. I need to get my thoughts together and get them to you in a report, but my overall impression is that I think the WCAP and the staff have made substantial progress on this issue and that things are looking brighter.

Some specific thoughts I have is that I think that downstream effects depend strongly on this rule of thumb on the debris bypass and I'm not so sure we have a technical basis for it that's believable yet and I also think it depends strongly on the assessment of the cross flow in the core and I'm not sure we have a technical basis for it under these low-flow conditions that we're talking about. So that's my two concerns there.

Even with these questions, though, I see that we probably are well along the way to resolving the downstream acceptability, which is a positive thing. I think we're getting close.

On the other hand, I'm still concerned about the upstream effects. I think there's so much uncertainty in the assessment of the blockage on the filter that I'm still worried about that issue.

You know, I think they've done the right things. They've increased the filter area and they've controlled the amounts of debris and tried to do things to minimize the chemical effects. Those are the right things to do, but personally I think I would have loved to seen some sort of defense in-depth measure that involved operator actions with the back-flow capability. I think that would resolve the issue, but, you know, that's just my personal opinion.

One item I brought up that's not -- I have never seen it discussed, it may have been, but boric acid dissolved in water when the water boils away at low pressure, the steam carries the boric acid with it, and I think on the long-term cooling conditions there's a race between the dilution of the boric acid and the built-in where there's xenon from the decay of the iodine as to whether or not you might go critical under long-term effects.

I have never seen an analysis of that and I don't know if it's an issue or not, but it's one I'm worried about.

CHAIRMAN BANERJEE: Well, if you have the partition coefficient, --

MR. KRESS: Yes.

CHAIRMAN BANERJEE: -- it's easy --

MR. KRESS: The partition coefficient.

CHAIRMAN BANERJEE: It will develop.

MR. KRESS: Yes, you can work it out and, of course, you know what the xenon, the decay rate it.

CHAIRMAN BANERJEE: Right.

MR. KRESS: Yes, you know, I'm not questioning the 800 degrees, but I haven't seen the basis for it. I don't know where it was. I haven't seen the tests that show that you don't embrittle the clad if you first quench it and then heat it back up to 800, but, you know, it sounds reasonable to me. I just wonder where I can find the data on it or the tests. So that was another issue that I'd like to --

MR. SCOTT: The discussion that the staff made in evaluating that issue which came in as a request from the owners' group is in one of those documents in your package.

MR. KRESS: Okay.

MR. SCOTT: So, you can at least see what the staff considered. I don't know about tests but you can consider the information they used to figure that out.

MR. KRESS: And finally, on this question of the uniform deposition on the core entrance, I don't see how you evaluate that. I think all you can do is really parameterize the decay itself and see what decay becomes unacceptable. I don't think you can do it in terms of blockage, overall blockage area. I just don't see how you can do that, but, you know, that's just my view of it.

I would focus on decay and then try to relate the decay somehow to what it might mean in terms of amount of blockage but I don't know how you make that connection.

CHAIRMAN BANERJEE: Well, Tom, they could look at experiments done in the past.

MR. KRESS: Oh, if you have experiments --

CHAIRMAN BANERJEE: They have roughly that whole area.

MR. KRESS: If you have experiments, that would be ideal way.

CHAIRMAN BANERJEE: Yes, they show that --

MR. KRESS: I'm assuming that they don't have any.

CHAIRMAN BANERJEE: Well, there's been a lot of experiments done and issues with this load, debris load, whether those experiments showed --

MR. KRESS: How much decay.

CHAIRMAN BANERJEE: -- uniform or non-uniform or blow-throughs or whatever.

MR. KRESS: But you're not going to get it in terms of blockage area. You're going to get it in terms of how much debris is there and what does that mean in terms of decay.

CHAIRMAN BANERJEE: Correct.

MR. KRESS: All right. So that was some advice, consulting advice to us.

CHAIRMAN BANERJEE: That's correct.

MR. KRESS: I was pretty pleased with the presentations and I think that we've seen some progress.

CHAIRMAN BANERJEE: Okay. I think we've taken -- Otto, next.

MEMBER MAYNARD: First of all, I want to say I agree with the overall conclusions, the overall recommendations that you're including. I think we've asked the questions about some of them and maybe some clarifications, but I think it's a good set of conditions that you're proposing there in the SER.

We have identified a number of look-ups and some additional information to be brought in and I think that from the answers, quite a bit of this in the RAIs. It would be good to take a look at it and there may be additional information over and above that that we've talked about.

I think one of the real issues gets into the plant-specific evaluations that's going to be coming up and I think that's appropriate that that be a key area because there really isn't any way to have a generic plant that kind of encompasses everything there. So, I do think that's going to be an important aspect and I agree.

One thing. I don't think we're ever going to have a definitive set of tests and quantitative information that's going to put this thing to bed forever, and I think we're always going to be faced with ultimately a qualitative decision on when's enough's enough. I don't think we're quite there yet. I think there's still unanswered questions, but I think we have to, you know, take a look at what point do we start reaching a point of diminishing returns such that, you know, resources would really be better spent on other issues that we may start getting more safety benefit out of.

I think we could question this thing to death and make a career out of it for the next 10 or 15 years. At some point, I think we have to say at this point with today's technology and with the variations we have, that we're able to provide reasonable assurance that we're protecting the health and safety of the public, and I think we need to keep that in mind.

I will say one thing for the owners' group and especially for the full committee meeting. You reference a test in there, that at the beginning of this meeting you said that you didn't, you really didn't have any information about that.

The way the question was answered is kind of like we took some numbers and put it in here. If you're referencing a test in your WCAP, you've got to be able to defend it at least to the applicability for what conclusions you're drawing from that. Whether it was your test or not, I think the way you answered some of those questions could give somebody the impression that we just found a test that we thought might have some good numbers and put it in there. You still have to defend it whether it was your test or not.

Some other things. You didn't talk too much about -- I think there's significantly more head available, depending on the location of break. You're either going to have it at the cold leg injection or the hot leg injection, other than the upper injection plants, still back up clear into steam generator tubes. It's necessary to get additional driver head there.

So, I didn't see a lot of talk about that, and the other thing is no matter how we resolve this thing, I still think the licensees need to be encouraged to remove as much problematic material as we can. I think that's really the ultimate answer to the whole thing because even if we resolve this at this point, who knows at a later date what may or may not come up. So, I think we need to be trying to remove as much of the problematic material, without replacing it with something that has more problems, but that's all the comments I have.

CHAIRMAN BANERJEE: Said?

MEMBER ABDEL-KHALIK: I agree with my colleagues' comments. I'd like to sort of point out just a few points.

I am concerned about this sort of rule of thumb about one cubic foot debris per thousand square foot area, especially when the assertion is made that the uncertainty in that number is plus or minus 10 percent. I just don't believe that.

The cognizant NRC person came and gave us a number of 1.3 in one of the tests. So right there, it's outside the plus or minus 10 percent range that you gave and my own intuition tells me that the uncertainty is more like an order of magnitude rather than a plus or minus 10 percent.

The second concern is the prototypicality of some of the experiments. For example, the CDI experiment, single bundle experiment that was presented. You know, how much do we believe these results? How well thought out were these experiments in terms of the selection of either the geometry or the operational parameters so that whatever results you come up with in those experiments would actually be directly applicable or transferrable or believable?

The issue, for example, of how big is the lower plenum in those experiments compared to a ratio of lower plenum volume in a full-sized core or, you know, the experiments were run at one flow rate, if I recall, you know. Are there data at other flow rates, particularly at the low flow rates that, you know, we are focusing on in terms of boil-off rates?

The third issue is the assumption or the impression that by doing a calculation with 99.4 percent core blockage, that this is indeed a bounding calculation. Having one free bundle and the rest of the core being blocked may not in fact be a bounding calculation.

I think the suggestion that Tom made about essentially doing the calculation parametrically and varying the loss coefficient at the inlet for the entire core, somewhere between 1.6 and the 10^{th} to the 9^{th} that you assume for the block region and finding out where do you get to the point where you cannot provide enough flow for, you know, the necessary amount of boil-off cooling, then you can translate that value of the loss coefficient into, well, how much of a layer do you need to increase the loss coefficient at the inlet to the core to give you that much of a loss coefficient.

Those are my comments. Thank you.

CHAIRMAN BANERJEE: Thanks. I think my colleagues have said almost everything I was going to say. The only thing I want to emphasize is that, in addition to the issues that you've listed and you send us information on, any information you can give us on what's happening to the bypass in terms of the data that you've been getting from your licensees would be very valuable.

We heard of one piece of data but I'm sure there's more data around. So, it would be very valuable if we could have some of that and take a look at it.

MR. SCOTT: We will -- what we would plan to give you would be the, for example, guidance we have on obtaining bypass information and whatever results we have. I don't think it's doable in a week to do a whole lot of data research, unless it's readily at hand. We'll do what we can.

CHAIRMAN BANERJEE: Okay. I understand that some of the data might be difficult to get hold of, but if you can get some of it or ask your licensees to give you some by the time of the subcommittee meeting.

MR. SCOTT: We can't get licensee data of any significance in a week.

CHAIRMAN BANERJEE: Not in a week. I'm saying in three weeks. Can you get it for the subcommittee meeting?

MR. SCOTT: I'm not sure what's out there. We'll see what we can do.

CHAIRMAN BANERJEE: All right. Because a lot, as Said points out, turns on this one cubic feet per thousand square feet.

MR. SCOTT: I clearly heard and wrote down that you would like more information on the basis for that number.

CHAIRMAN BANERJEE: Right.

MR. SCOTT: Got it.

CHAIRMAN BANERJEE: Okay.

MR. SCOTT: Understood.

CHAIRMAN BANERJEE: Well, I think with that, if nobody has any more comments or questions, I'm going to thank you for a very interesting and productive meeting. I was reassured by some of these calculations because the downstream effects of all this has always been something that have been worrying and the fact that you can actually block off 99.4 percent of the core at the entrance and still have sufficient cooling is encouraging.

Now what that means in terms of, of course, the thickness of the fiber bed and all has to be worked out, but it's a big step in the right direction.

So, thank you very much.

(Whereupon, the meeting adjourned at 6:51 p.m.)

CERTIFICATE

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

Name of Proceeding: Advisory Committee on Reactor Safeguards

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.

Charles Morrison
Official Reporter
Neal R. Gross & Co., Inc.

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Protecting People and the Environment

Safety Evaluation of WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid"

Staff Presentation to:

Advisory Committee on Reactor Safeguards

Thermal-Hydraulics Subcommittee

March 19, 2008

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Staff Presenters

- Dr. Ralph R Landry, Senior Level Advisor, DSRA/NRO
- Paul Klein, Senior Materials Engineer, DCI/NRR
- Dr. Robert Litman, Consultant, Environmental Management Support

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Outline

- Overview of WCAP-16793-NP Approach
- Regulatory Review
- Technical Review
  - Core Inlet Blockage
  - Boric Acid Precipitation
  - Upper Plenum Injection Plants
  - Fuel Swelling and Blockage
  - Local Heating of Fuel Rods
  - Results of WCAP-16530 Material Dissolution
  - Thickness of Fuel Deposits
  - Application of WCAP-16793-NP
  - Acceptance Criteria
  - Conditions and Limitations
  - Conclusions

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WCAP-16793-NP Approach

1. A limit on the maximum temperature of fuel clad is established based upon a conservative value that prevents fuel damage (in accordance with 10CFR50.46)
2. Industry recognized models for deposition of solids and calculation of temperature increases based on heat transfer coefficients are used
3. A flow simulation code, WCOBRA/TRAC is used to assess limit on flow reduction and still achieve adequate core cooling
4. *The results of the WCAP-16530 total material dissolution are available to be deposited on the core surfaces

* Addressed in chemical effects slides

WCAP-16793-NP Approach (cont'd)

5. Size and quantity of fibrous material entering the lower core region is estimated from the containment sump screen dimensions and plant fiber bypass tests
6. The deposition of this material on the lower core plate, leading to flow blockage, is assessed
7. Particulate and fibrous matter that passes through the lower core plate is evaluated for flow blockage and deposition effects
8. * The thickness of the fuel deposits (oxide + crud + chemical deposit) formed are calculated using LOCADM based on fuel decay heat, the mass of materials present, and the core surface area

* Addressed in chemical effects slides

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Licensee Use of WCAP-16793-NP

- Licensees are likely to take credit for WCAP-16793-NP as bounding for their plants in showing that in-vessel downstream effects will not cause unacceptable impacts on the fuel
- Application of WCAP-16793-NP is to be in accordance with conditions and limitations contained in the staff safety evaluation

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Licensee Use of WCAP-16793-NP (cont'd)

- Licensees are expected to verify that the assumptions in the WCAP-16793-NP methods are conservative with respect to their individual plants
- Licensees may choose to develop and substitute plant-specific data, such as debris content, chemicals, strainer efficiency, etc.

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Regulatory Evaluation

- 10 CFR 50.46(b)(5) – After any calculated successful initial operation of the ECCS [emergency core cooling system], the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity in the core

Regulatory Evaluation (cont'd)

- Generic Letter 2004-02 – calls for holders of operating licenses for pressurized water reactors to perform evaluations of the ECCS and the containment spray recirculation functions. Evaluations are to include potential for debris blockage at flow restrictions within the ECCS flow path downstream of the sump screen, including potential blockage at fuel assembly inlet debris screens, spacer grids, and potential to impede or prevent recirculation of coolant to the core

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Regulatory Evaluation (cont'd)

- Staff clarification (letter to Westinghouse dated August 16, 2006, ML062070451) :
  - Regulatory requirements and acceptance criteria after core quench
  - Mission time for evaluating debris ingestion

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Regulatory Evaluation (cont'd)

- Cooling capability despite challenges from chemical or physical effects - as demonstrated by no significant increase in calculated peak cladding temperature
- Mission time is demonstrated when bulk and local temperatures are shown to be stable or continuously decreasing

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Blockage at Core Inlet - Analytic

- Core blockage calculations conducted by the PWROG (WCOBRA-TRAC) and the staff (RELAP5 and TRACE)
- Consistently showed high inlet blockage, on the order of 95-99%, could be tolerated with heatup ~10 °F

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Blockage at Core Inlet – Analytic (cont'd)

- Staff analyses using TRACE for unblocked, 75% blocked, 87.5% blocked and 95% blocked found maximum cladding temperature increase of 10 °F for blockage. (ML070650576)
- Collapsed liquid level showed very little change with blockage
- While void fractions were larger immediately above blocked area, at the core exit there were no significant differences

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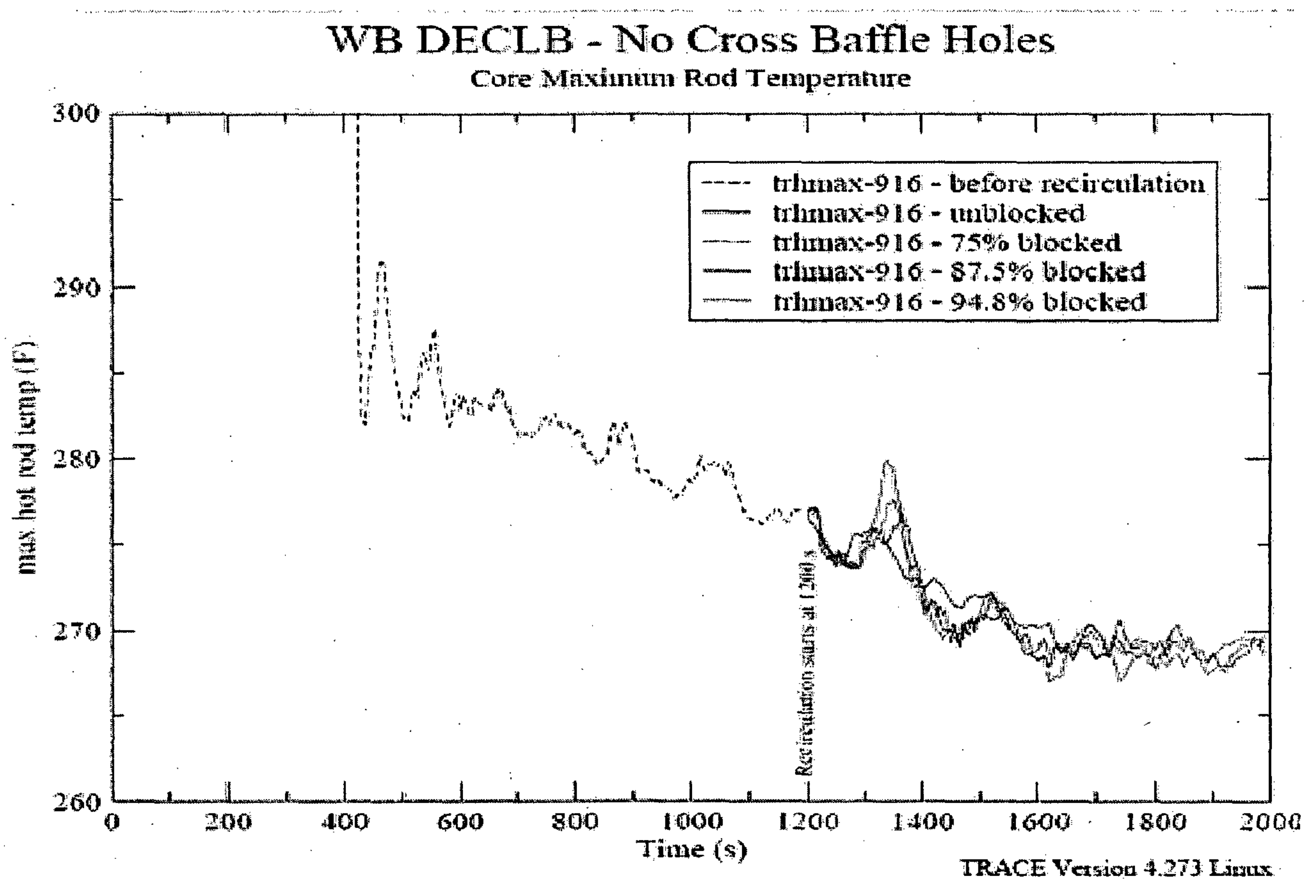
Blockage at Core Inlet – Analytic (cont'd)



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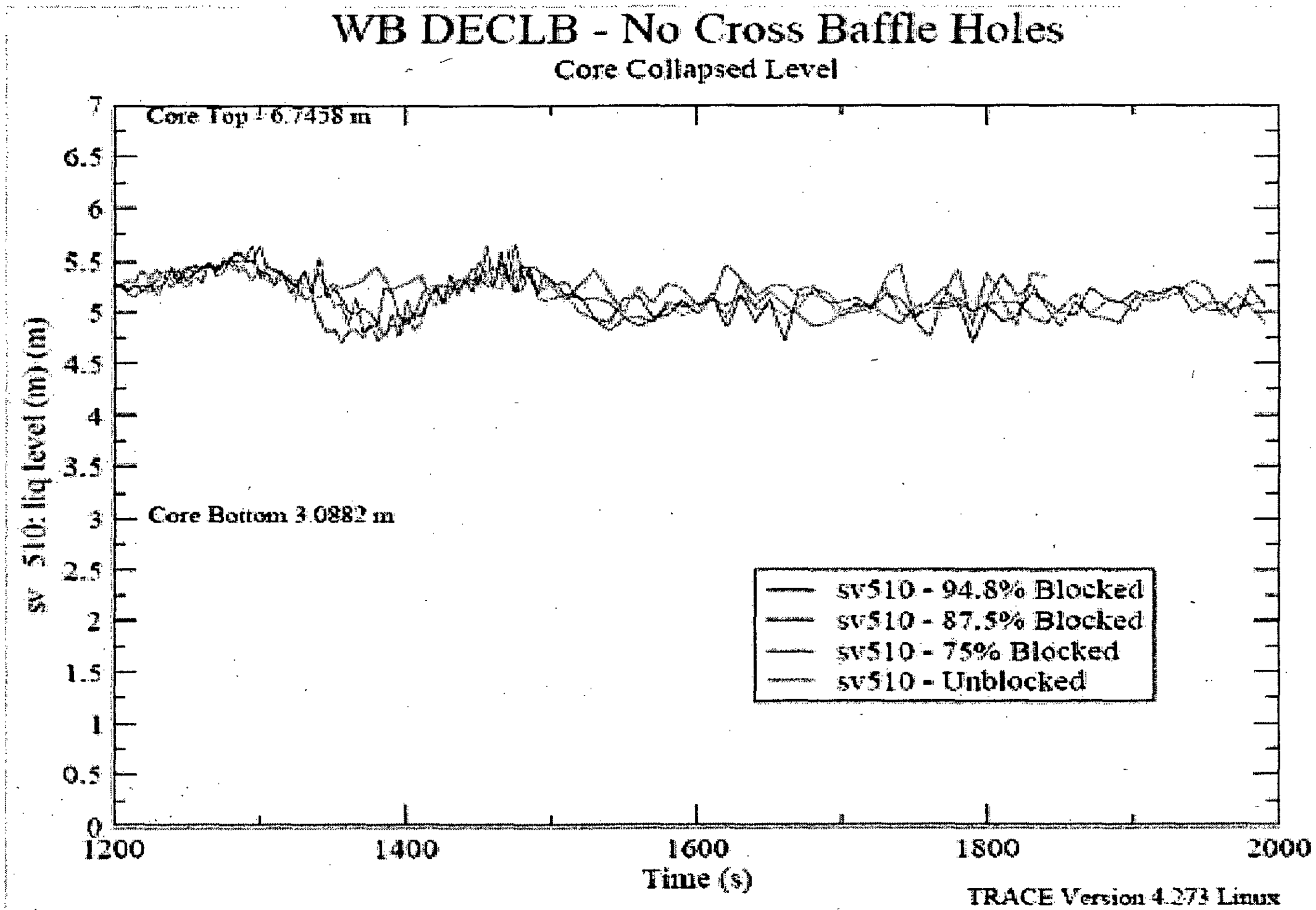
Blockage at Core Inlet – Analytic (cont'd)



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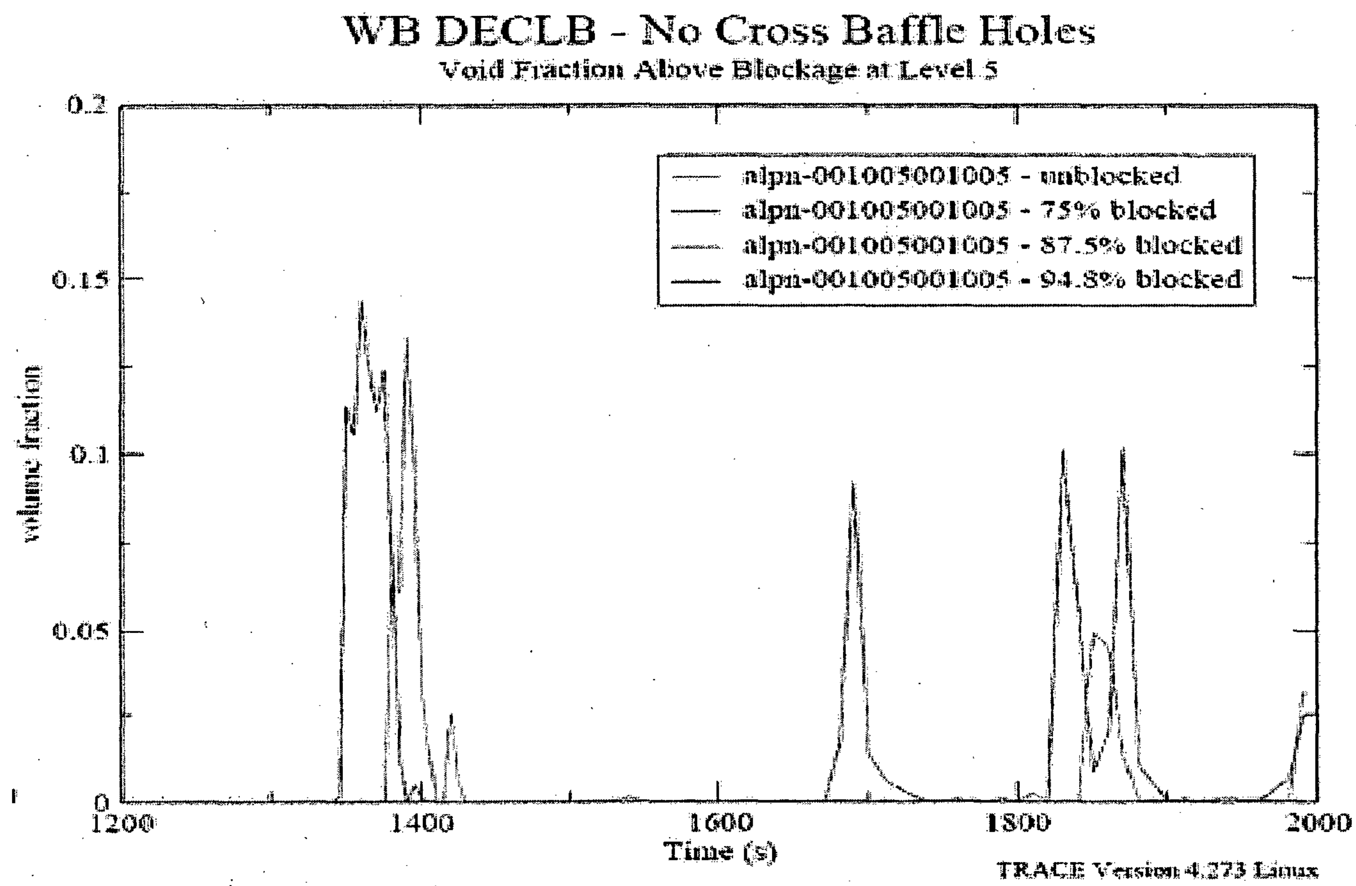
Blockage at Core Inlet – Analytic (cont'd)



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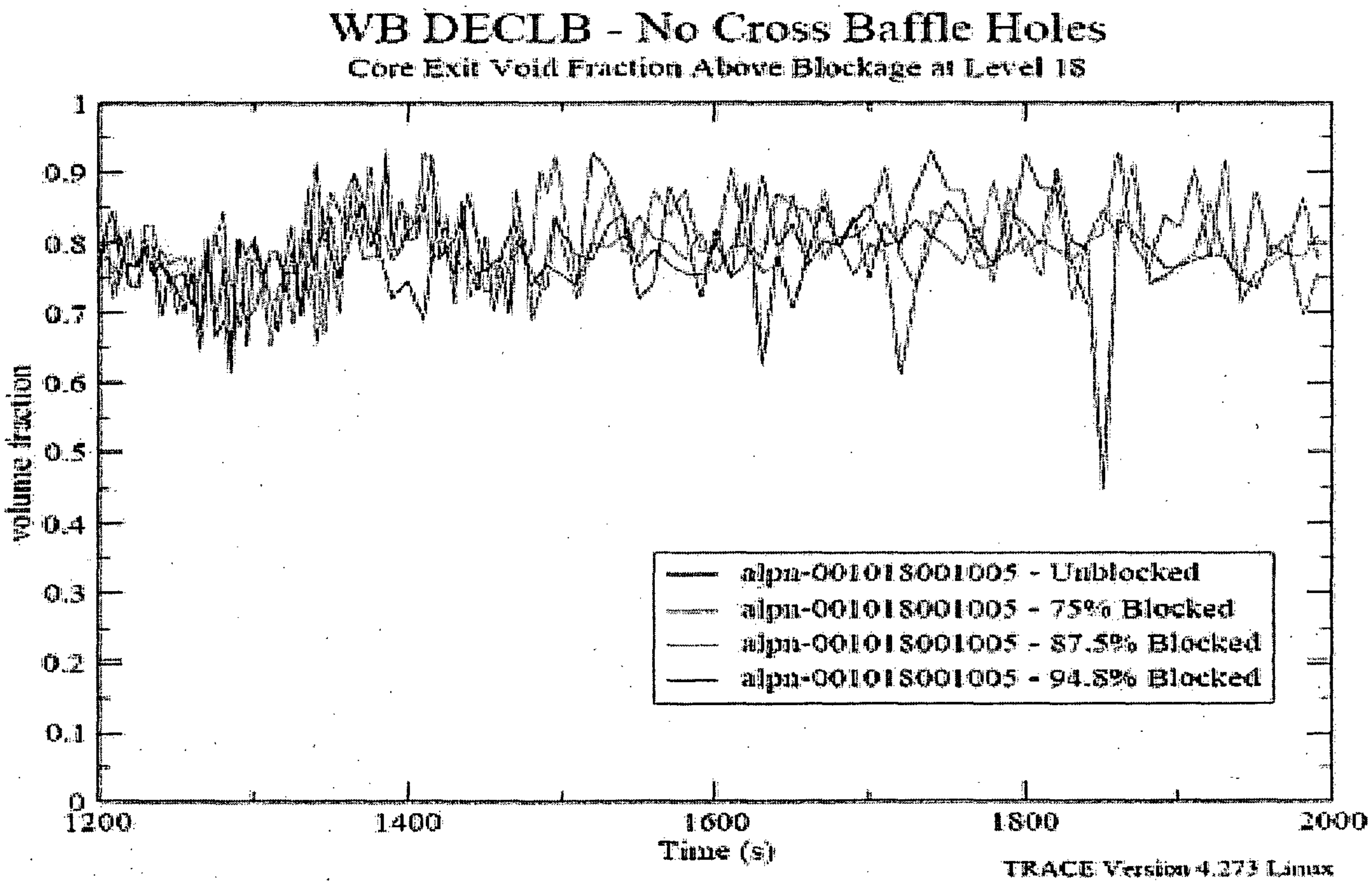
Blockage at Core Inlet – Analytic (cont'd)



Blockage at Core Inlet – Analytic (cont'd)

- Staff also performed FLUENT computational fluid dynamics (CFD) analysis of core flow patterns using 410,000-cell model
- Results indicate that radial flow spreads very quickly downstream of the blockage location
- Concluded areas of the core above blocked portions of assemblies are effectively cooled for all cases analyzed

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Blockage at Core Inlet - Experimental

- Continuum Dynamics, Inc (CDI) strainer tests included a demonstration of fibrous blockage of a simulated fuel assembly
- Fibers were captured at lower fuel nozzle (Guardian Grid) supplied by Calvert Cliffs
- Fiber did not accumulate sufficiently within the assembly to cause internal blockage
- Fibrous material was from screen/strainer bypass
- Staff considers test results to provide qualitative information only due to non-prototypical features

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Blockage at Core Inlet – Experimental (cont'd)

- Fuel assembly simulator was only 1 ½ feet long, plastic rods instead of Zircalloy, two spacer grids which did not provide prototypical assembly pressure drop
- PWROG stated that the bounding head loss assuming collection of 21.7 ft^3 fibrous debris and 1389 lb_m particulate debris at core entrance would be 0.37 psi pressure drop increase

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Blockage at Core Inlet

- Although the staff does not accept the CDI demonstration as a rigorous test, it does agree with the conclusions that adequate core flow will not be inhibited
- PWROG and staff core cooling analyses demonstrate that core cooling can be maintained even with core inlet blockage in the 95-99% range

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Boric Acid Precipitation

- Licensing basis boric acid precipitation analyses have been reviewed and approved by the staff
- WCAP-16793-NP contains qualitative guidance on applying blockage and lower plenum debris to boric acid calculations
- The staff agrees with the topical report (TR) that it must be shown on a plant-specific basis that blockage due to debris and reduction in lower plenum mixing volume does not adversely affect conclusions regarding boric acid dilution and precipitation

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Upper Plenum Injection Plants

- PWROG presented the position that debris introduced through upper plenum injection would be swept through the UP and out the hot legs
- Also, the PWROG stated that in the case of a CL break, the CDI test supports the position that debris would not compact and block the core
- The staff does not agree – the CDI test was for injection into the lower plenum with flow up through the core
- Flow into the upper plenum will settle and fall into the core
- However, the large margins demonstrated to core blockage and the amount of blockage necessary for core heat up indicate that adequate decay heat removal will be maintained

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Fuel Swelling and Blockage

- The effect of swelling, rupture and blockage of the fuel cladding was not considered in WCAP-16793-NP
- Analyses indicate that up to 10% of the fuel rods may experience swelling and rupture
- Based on prior LOCA analyses, the staff agrees with the PWROG that acceptable core cooling will continue with blockage due to fuel cladding swell and rupture and debris capture
- The PWROG is expected to add discussion of this effect to the revision to WCAP-16793-NP

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Local Heating of Fuel Rods

- Local fuel rod heating can result from: oxide layer, crud layer, debris plate out, and debris buildup between the fuel rod and the spacer grid
- The staff position is that local heatup of cladding should not result in a PCT that exceeds 800 °F following core quench and reflood

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Local Heating of Fuel Rods - Oxide

- Cladding oxidation estimation is required as part of the LOCA analysis prescribed in 10 CFR 50.46
- Oxidation should include pre-accident oxidation as part of the acceptance criterion limit of 17%
- The WCAP-16793-NP prescribed oxidation value for input to LOCADM should be the limiting value of 17%

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Local Heating of Fuel Rods – Oxide (cont'd)

- The WCAP-16793-NP methodology is based on an oxide layer thermal conductivity of 1.61 BTU/(hr-ft-^{o}F)
- TR states that increasing the oxide layer by 50%, from 4 mils (100 microns) to 6 mils (150 microns), results in a temperature increase of 2 ^{o}F

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Oxide Layer – High Burnup

Cladding	Reactor (Discharge)	Burnup GWd/MTU	Corrosion Layer (microns)
15x15 Zry-4	Robinson (4/1995)	64	71-75 95
17x17 Zirlo	North Anna (3/2001)	70	43±2 (43±2)
17x17 M5	Ringhals (7/2003) North Anna (5/2004)	63 68, 72	12±1 ~ 10-20

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Local Heating of Fuel Rods - Debris

- WCAP-16793-NP assumed two cases for debris deposition: layer is 110 mils behind the grid which would bridge the gap between adjacent fuel rods, and a layer of 50 mils so no bridging occurs
- A conservative thermal conductivity of 0.1 BTU/(hr-ft-°F) was used for the debris
- Calculated peak cladding temperatures in these cases were 738 °F for bridging and 474 °F for non-bridging, below the limiting PCT of 800 °F

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Local Heating of Fuel Rods – Debris (cont'd)

- Previous review of insulation plate out on metallic surfaces (1979) found that very little material would adhere under:
  - Submersion of rod specimen at 2200 °F in a slurry of insulation
  - Nucleate boiling of a slurry on the surface for 2 hours
  - Film boiling of a slurry on the surface for 2 hours
- Based on review of the above noted information, the staff agrees that the assumed amount of buildup of surface debris is conservative

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Local Heating of Fuel Rods - Crud

- Crud is assumed to be present in a layer of 50 microns for first cycle fuel and 100 microns for second and third cycle fuel
- Maximum measured crud thickness from an operating PWR is 127 microns

Local Heating of Fuel Rods – Crud (cont'd)

- Limiting crud thermal conductivity referenced of 0.3 BTU/(hr-ft-°F) falls at the lower end of the measured boiler tube crud thermal conductivity, 0.29-0.55 BTU/(hr-ft-°F) for calcium-rich scale
- WCAP-16793-NP methodology uses a crud thermal conductivity of 0.30 BTU/(hr-ft-°F), the value for sodium aluminum silicate, for bounding cases when the type of scale is uncertain
- The staff agrees that this is a conservative value of thermal conductivity

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Local Heating of Fuel Rods

- Combining the above effects, 4 mils of oxide, 4 mils of crud, and 50 mils of chemical precipitate, with only radial heat transfer, results in a predicted peak cladding temperature of 560 °F for a 0.360 in rod, 713 °F for a 0.416 in rod, and 714 °F for a 0.422 in rod, all less than the staff limiting PCT of 800 °F

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Chemical Effects - Outline

- WCAP-16530-NP, “Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids To Support GSI-191,” provides the chemical source term for the WCAP-16793 analysis
- WCAP-16793-NP, “Evaluation of Long-Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid,” discusses treatment of chemical effects in the reactor vessel

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WCAP-16530-NP

- ACRS T/H Subcommittee last briefed on WCAP-16530-NP in May 2007
- NRC staff review is now complete, SE available in ADAMS, ML073520891
- The WCAP surveyed the materials used in the plants and applied matrix testing to these materials based on containment post-LOCA conditions
- Key elements of WCAP-16530-NP are dissolution tests, precipitation tests, and a method for creating surrogate chemical precipitate

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WCAP-16530-NP Staff Review

- Technical assistance for NRC staff review provided by Argonne National Laboratory (ANL) and by a member of the chemical effects peer review panel sponsored by the NRC Office of Nuclear Regulatory Research
- NRC staff concluded some confirmatory testing was needed to complete our review
- Bench-top tests and head loss tests performed at ANL to evaluate WCAP surrogate precipitate
- Supplementary material leaching tests performed at Southwest Research Institute (SwRI)

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Conservatisms in WCAP-16530-NP

- All dissolved aluminum and all calcium in presence of phosphate is assumed to precipitate
- Model does not consider rate effects that may delay precipitation and result in much greater pump net positive suction head margins
- Passivation of aluminum by phosphate or silicate is not considered
- Small amounts of the WCAP surrogate precipitate produced high head loss
  - ANL vertical head loss loop tests
  - Vendor testing
- Limited scope bench-top tests at SwRI
  - Replicate tests - concentration of leachate similar to or less than WCAP
  - No precipitates observed in tests of other non-metallic materials that were not tested in the WCAP program
- Vendors' 30-day integrated test results show WCAP-16530 predictions are conservative

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WCAP-16530-NP Safety Evaluation, NRC Conditions and Limitations

- NRC pursuing scoping analyses to evaluate remaining peer review panel issues
- Does not address WCAP-16785-NP* (refinements to WCAP-16530-NP)
- Integrated head loss tests that use a time based addition of WCAP precipitate should use an adjusted aluminum release rate
- More stringent precipitate settlement acceptance criteria for WCAP precipitate used in integrated head loss testing
- Account for sodium aluminum silicate precipitate solubility if head loss tests use deionized water

* Staff has provided comments outside WCAP-16530-NP review

Chemical Effects in WCAP-16793-NP

- Evaluation of chemical effects on long term cooling in the Reactor Vessel

WCAP-16793-NP – LOCADM

- Inputs from core design parameters such as:
  1. Decay heat
  2. Fuel surface area
  3. Maximum zirconium oxide thickness
  4. Crud thickness based on fuel age
  5. Thermal conductivity values for crud and oxide
  6. Depth in the core and
  7. Fuel element power factor
- Maximum deposition rate occurs when local node conditions predict boiling

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LOCADM – Chemical Source Term Assumptions

- WCAP-16793 uses the data for total dissolved materials and precipitated chemicals from WCAP-16530 as the starting point for all ionic materials that can be deposited on the fuel
- Deposition of species on the fuel increases the dissolution rate outside the reactor since the overall solution concentrations are lowered
- No deposition occurs on system surfaces outside the reactor core. All material that is transported to the fuel clad surfaces during boiling is deposited
- Once formed, deposits are not thinned by flow attrition, dissolution, or any other means

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LOCA-DM Chemical Deposit

- Two thermodynamic programs (OLI StreamAnalyzer and HSC Chemistry) predictions guided selection of a bounding chemical deposit thermal conductivity
- A lower bound value of 0.11 BTU/(hr-ft-°F) is used, from the lower bound value for a sodium aluminum silicate deposit

Example thermal conductivity values, BTU/(hr-ft-°F):

fiberglass (dry to water/steam mix) composite foam insulation	.05 to .6 .09 to .10
sodium aluminum silicate	.12 to .23
calcium carbonate	.34 to .52
calcium sulfate	.46 to 1.6
glass	.50 to .80

Staff Assessment of WCAP-16793-NP Rationale for Accepting Chemical Effects Evaluation

- WCAP-16793 uses the data for total dissolved materials and precipitated chemicals from WCAP-16530 and assumes all ionic material is available to be deposited on the fuel. This provides a high degree of conservatism given that precipitates may settle on the containment floor, be captured in the debris bed that forms on a sump strainer or attach to other system surfaces such as in heat exchangers

- The assumed LOCADM chemical deposit thermal conductivity value 0.11 BTU/(hr-ft-°F) is judged to be conservative

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Rationale for Accepting Chemical Effects Evaluation (cont'd)

- Westinghouse calculations showed the following conditions would not cause peak clad surface temperature to reach 800 F:
  - the highest power fuel rod
  - decay heat level at the time switchover to recirculation
  - 100 micron zirconium oxide layer, 100 micron crud layer
  - 50 mils chemical deposit, 0.1 BTU/(hr-ft-°F)
  - Assuming no axial heat conduction occurs

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Rationale for Accepting Chemical Effects Evaluation (cont'd)

- LOCADM calculations for a sample high-fiber plant, 7000 cubic feet of fiberglass debris and 80 cubic feet of calcium-silicate debris, yielded 10 mils maximum chemical deposit thickness

- Therefore, the NRC staff concludes there is a large margin between the chemical deposit predicted for a high-fiber plant with large amounts of calcium silicate insulation and the amount of deposit that would cause the maximum peak clad temperature to exceed the acceptance criteria

Application of WCAP-16793-NP

- Following the procedures in WCAP-16793-NP, and the standard methods discussed, plant-specific evaluations are expected to be able to demonstrate adequate long-term core cooling in the presence of post-LOCA debris
- The PWROG will provide a guidance document to licensees on implementation of WCAP-16793-NP
- Licensees will be provided with LOCADM code, instructions on needed input, and sample calculations
- The staff position is that personnel performing these analyses should receive adequate training and qualification prior to performing the analyses

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Acceptance Criteria

- PWROG states that long-term core cooling acceptance bases are met when
  - Decay heat removal is provided such that core peak cladding temperatures do not exceed 800 °F
  - Boric acid concentration in the core region is prevented from exceeding the precipitation limit
- The staff agrees that adherence to the methods and procedures presented will provide reasonable assurance that adequate core cooling will be maintained
- The staff position is that the temperature limit of 800 °F is the predicted peak cladding temperature rather than the core average temperature

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Conditions and Limitations

- Licensees must demonstrate applicability of previous sump strainer tests or perform plant-specific tests
- Plant-specific evaluations should verify applicability of WCAP-16793 blockage conclusions
- If credit is taken for alternative flow paths, such as core baffle plate holes, it shall be demonstrated that the paths would be effective and not become blocked

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Conditions and Limitations (cont'd)

- Licensees shall show that core inlet blockage will not invalidate existing post-LOCA boric acid dilution analysis
- WCAP-16793-NP should be revised to include discussion of fuel swelling and blockage
- Assumed cladding oxidation of 17% shall be used with LOCADM
- Peak cladding temperature limit of 800 °F shall be a long-term cooling acceptance basis

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Conditions and Limitations (cont'd)

- Default crud thickness input for LOCADM shall be 127 microns
- Licensees shall provide a technical justification for use of a chemical deposit thermal conductivity value greater than 0.11 BTU/(hr-ft-°F)
- Licensees shall accelerate the aluminum release rate by a factor of 2 until the WCAP-16530-NP predicted total aluminum amount is reached

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Conclusions

- The staff concludes that application of the procedures and methods described in WCAP-16793-NP will provide an acceptable plant-specific evaluation of the plant's ability to adequately remove long-term decay heat from the core following a postulated loss-of-coolant accident

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WCAP-16793-NP
Safety Evaluation Report

Backup Slides

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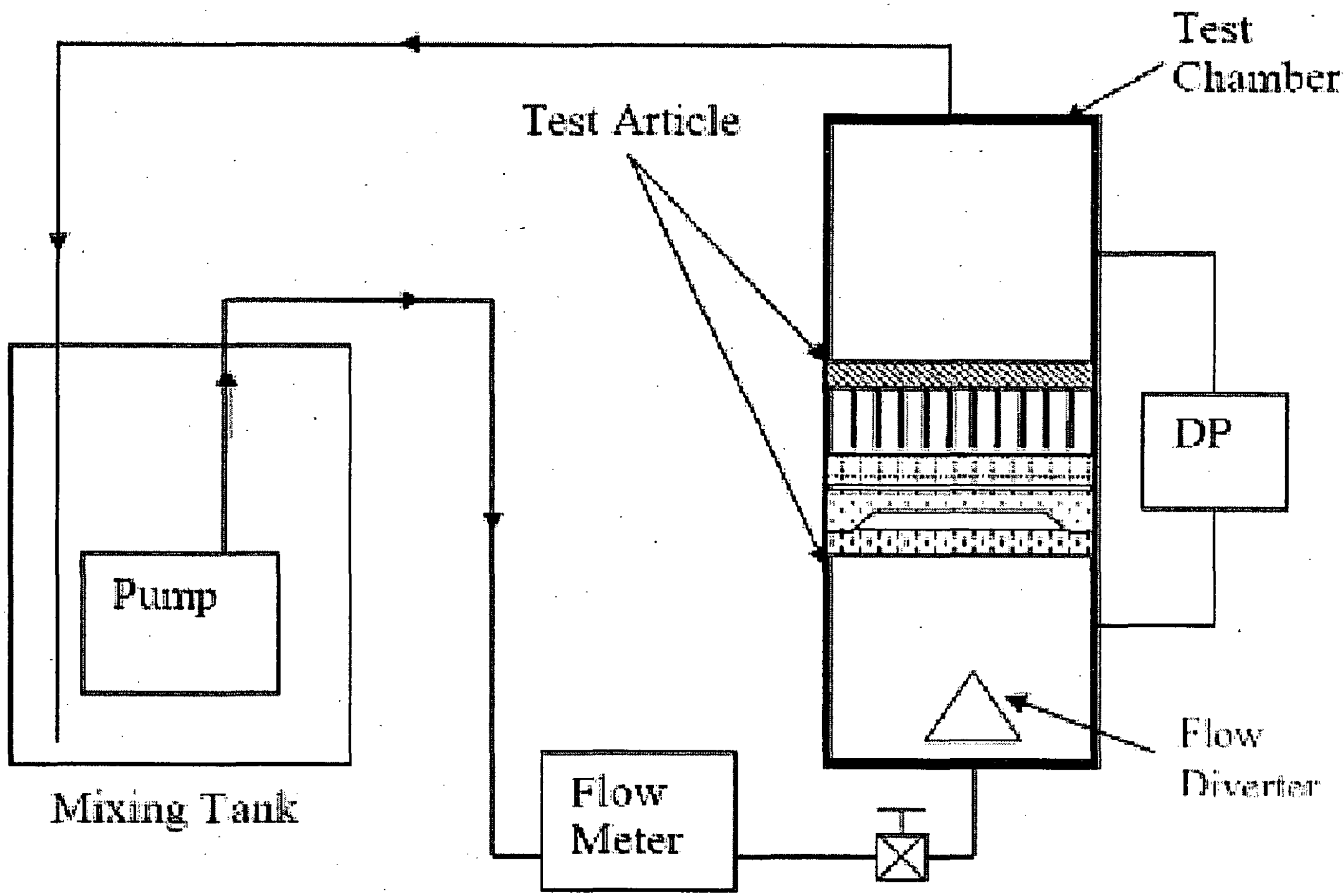
CDI Test Rig



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CDI Test Rig

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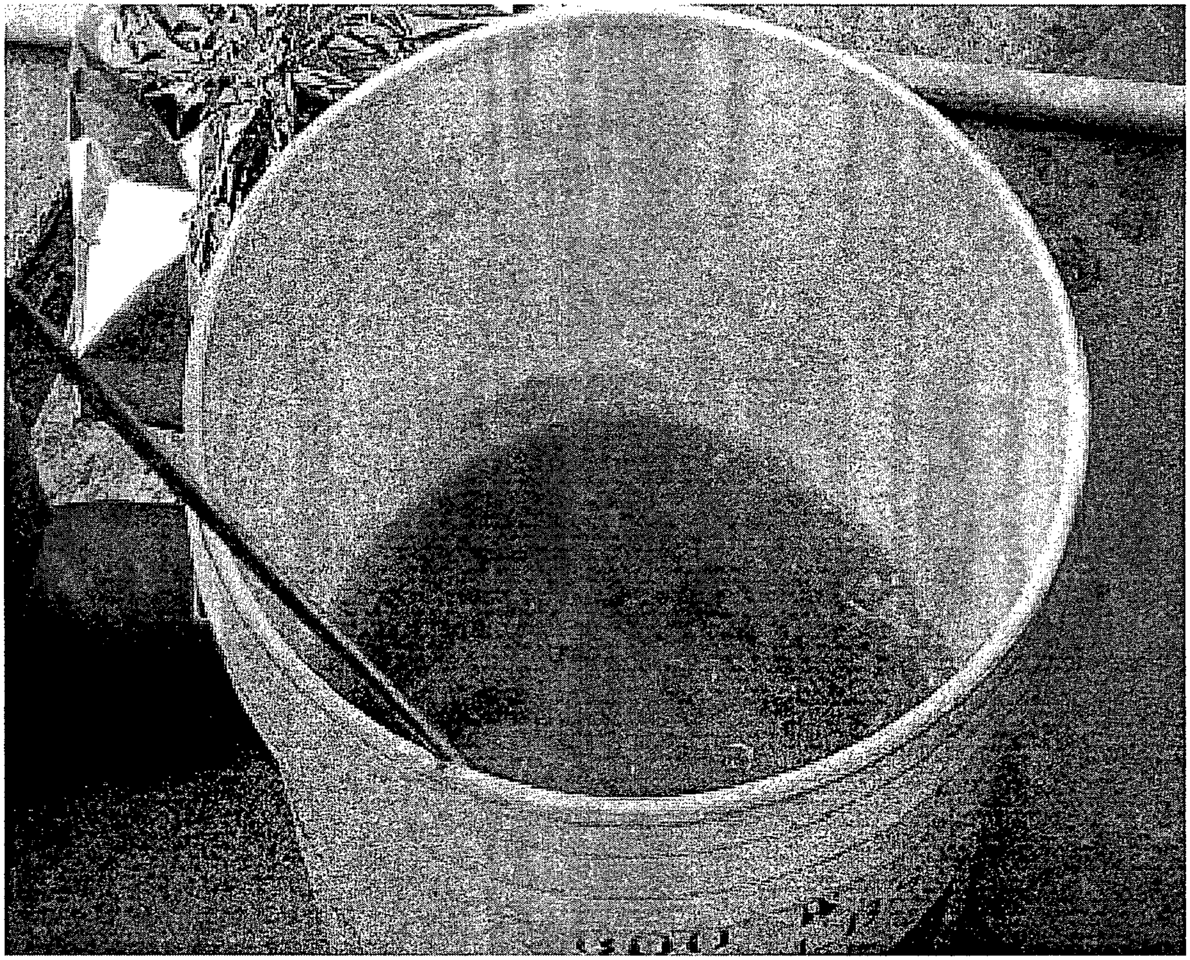
CDI Test Rig



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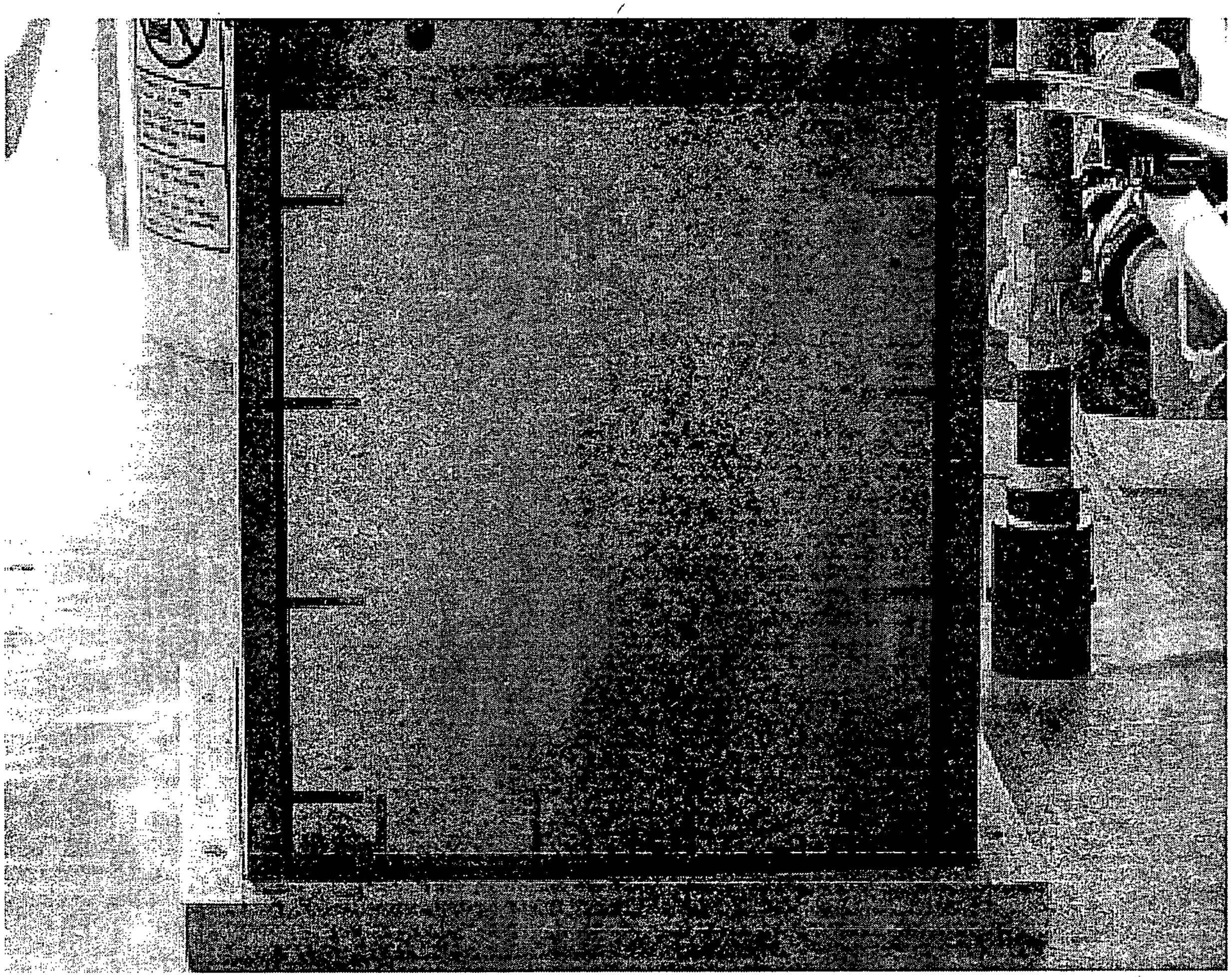

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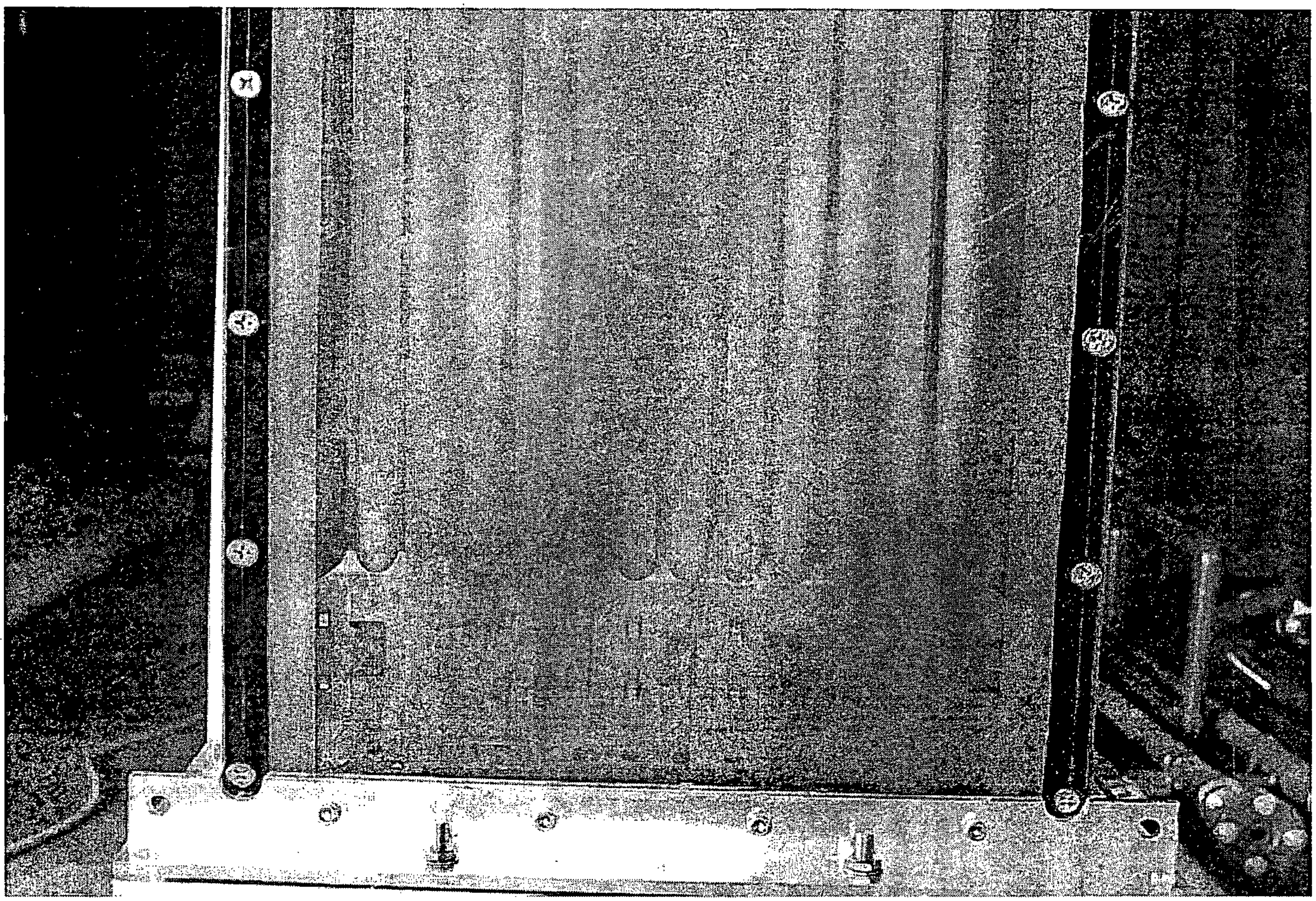

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LOCADM Validation

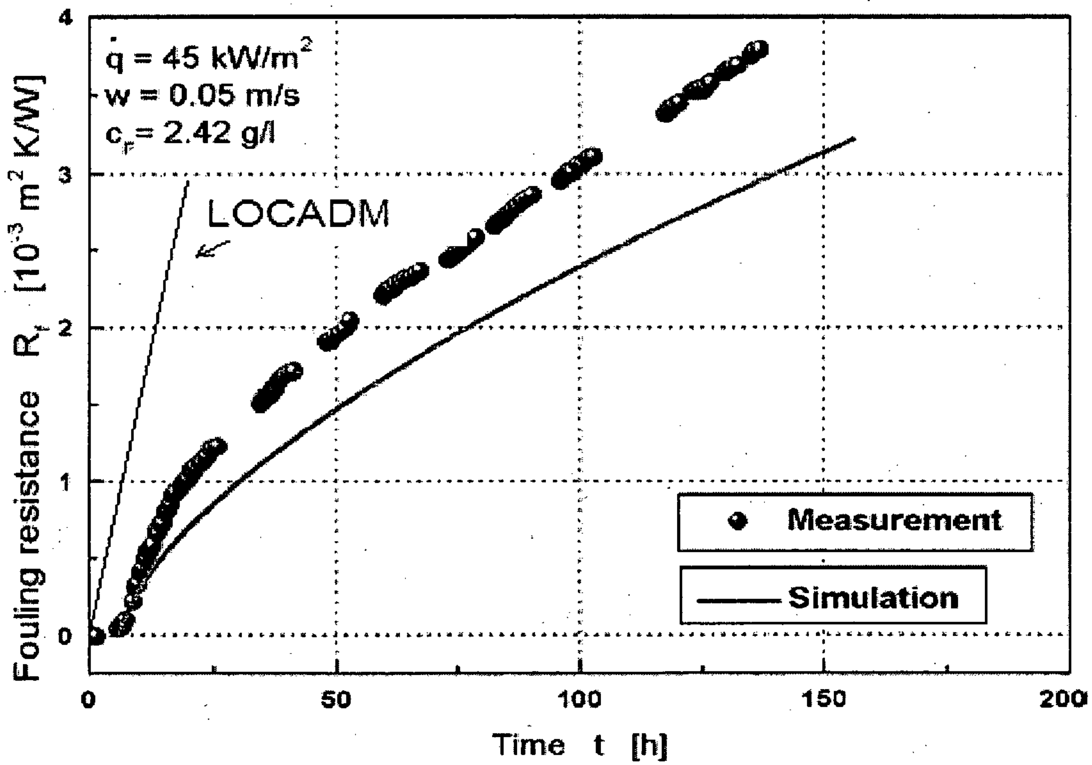


Figure E-3. Experimental Fouling Resistance for Calcium Sulfate Deposition (3) Compared to the LOCADM Calculated Fouling Resistance

WCAP-16793-NP, Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid;

An Overview

PWR Owners Group

March 19, 2008

PWROG Program Objective

- Demonstrate sufficient long-term core cooling achieved for PWRs to satisfy requirements of 10 CFR 50.46 with debris and chemical products that might be transported to the reactor vessel and core by the coolant recirculating from the containment sump
  - Removal of decay heat
  - Maintain coolable core geometry

PWROG Program Applicability

- Results of this program apply to the fleet of PWRs, regardless of the design
  - B&W
  - Combustion Engineering
  - Westinghouse
    - 2-Loop Design
    - 3-Loop Design
    - 4-Loop Design

PWROG Program Results

- Documented in report WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid"
- Draft Safety Evaluation (SE) prepared (ADAMS ML080600876)

Topics Considered under GSI-191

- Topics must be treated in an integrated manner
  - Blockage at the core inlet (top or bottom)
  - Collection of debris on fuel grids
  - Collection and deposition of material on fuel cladding
- When considered in total, 10CFR 50.46 criteria are satisfied

Long-Term Core Cooling Success

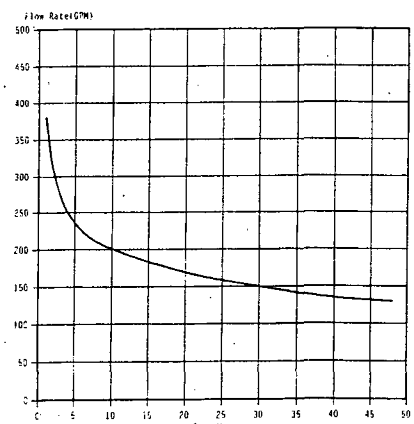
- Long-term cool cooling (LTCC) successful if:
  - Maximum clad temperature < 800°F
  - Thickness of cladding oxide and fuel deposits < average of 0.050 inches in any fuel region.
- These are:
  - Applicable after the initial quench of the core
  - Consistent with the long-term core cooling requirements of 10 CFR 50.46 (b)(4) and 10 CFR 50.46 (b)(5).
    - Provide for demonstrating that local temperatures in the core are stable or continuously decreasing, and,
    - Debris entrained in the cooling water supply will not affect decay heat removal
- Do not present, nor are they intended to be, new or additional long-term core cooling requirements

Basis for LTCC Success

- The 800°F temperature
  - Selected based on autoclave data that demonstrated oxidation and hydrogen pickup to be well behaved at and below the 800°F temperature and the reduction in cladding small
- The 0.050 inch limit for oxide plus deposits
  - Selected so as to preclude the formation of deposits that would bridge the space between adjacent rods and block flow between fuel channels.

Coolant Flow Required for LTCC

- Flow rates required to match boil-off becomes small quickly following the postulated event
  - Within four (4) hours following a postulated LOCA, the required flow to match boil-off is ~250 gallons per minute
  - At 30 hours, the flow required to match boil-off is ~150 gallons per minute



Specific Areas Addressed

- Blockage at the core inlet (top and bottom)
- Collection of debris on fuel grids/rods
- Collection/production of material on fuel cladding
- Protective coating debris deposited on fuel rods
- Boric acid precipitation

Blockage at the core inlet

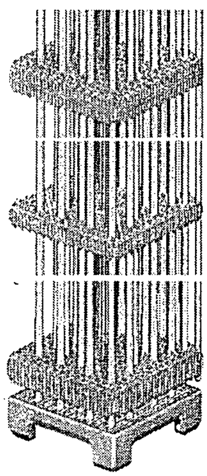
- Adequate flow to remove decay heat will continue to reach the core even with debris from the sump reaching the RCS and core
  - Sump screen bypass testing indicates:
    - Fiber bypass ≈ 1ft^3 debris / 1000 ft^2 screen area
    - Fiber length ≤ 2000 μm
  - Sump screen hole size limits amount and size of bypassed particulates
    - Hole sizes ≤ 0.10 inches
  - Single assembly testing indicates that fibrous and particulate debris bypassing sump screen is not likely to build an impenetrable blockage at the core inlet
  - Defense in Depth analyses of large blockages at core inlet demonstrate that core decay heat removal will continue

Fuel Assembly Head Loss Test

Summary of Head Loss Data for Observation Configuration						
Flow Rate (gpm)	Fibrous Debris			Particulate Debris		Measured Head Loss (in_{H_2O})
	Mass - One Assembly	Volume - One Assembly	Volume – At Core Entrance	Mass - One Assembly	Mass – At Core Entrance	
6	0.04 lb_m	0.017 ft^3	3.62 ft^3	0.0 lb_m	0.0 lb_m	0.4
				0.4 lb_m	86.8 lb_m	0.8
6	0.06 lb_m	0.025 ft^3	5.43 ft^3	0.0 lb_m	0.0 lb_m	1.2
				1.2 lb_m	260.4 lb_m	2.9
6	0.12 lb_m	0.050 ft^3	10.85 ft^3	0.0 lb_m	0.0 lb_m	1.9 – 2.5
				1.6 lb_m	347.2 lb_m	4.5 – 7.0
6	0.24 lb_m	0.100 ft^3	21.7 ft^3	0.0 lb_m	0.0 lb_m	3.8 – 5.8
				6.4 lb_m	1388.8 lb_m	10.2
6	0.36 lb_m	0.150 ft^3	32.55 ft^3	0.0 lb_m	0.0 lb_m	12.9
				16 lb_m	3472 lb_m	38.5
6	0.48 lb_m	0.200 ft^3	43.40 ft^3	0.0 lb_m	0.0 lb_m	0.8 – 16.3[3]
				16 lb_m	3472.0 lb_m	> 60
6	0.96 lb_m	0.400 ft^3	86.80 ft^3	0.0 lb_m	0.0 lb_m	24.1
				6.4 lb_m	1388.8 lb_m	> 60

Collection of Debris on Fuel Grids

- Decay heat will continue to be removed even with debris collection at the fuel assembly spacer grids
  - Test data demonstrates any debris that bypasses the screen is small dimensionally and volumetrically and consequently is not likely to collect at grid locations
  - Any blockage that may form will be limited in length and not be impenetrable to flow



Collection of Debris on Fuel Grids

- For Defense In Depth, numerical and first princile analyses demonstrate that core decay heat removal will continue with complete local fuel grid blockage
  - One dimensional radial heat transfer calculation

Collection of Material on Fuel Clad

- Fibrous debris, should it enter the core region, will not tightly adhere to the surface of fuel cladding
  - NUKON OFC-1 Report
    - Submersion of a rod heated to 2200°F in a fiber slurry
    - Nucleate boiling of a heated rod in a slurry
    - Film boiling of a heated rod in a slurry
  - With Supporting Safety Evaluation

Collection of Material on Fuel Clad

- A method to predict chemical deposition of fuel cladding was developed (LOCADM spreadsheet)
  - Uses an extension of the chemical effects method developed for sump chemical effects (WCAP-16530-NP-A)
  - Assumes that deposition is driven by boiling
  - All coolant impurities, regardless of chemical form, that are transported to the fuel surface would be deposited by boiling
  - Once plated out, remains on rod (no re-dissolution)
- Used to demonstrate < 50 mil build-up on clad

Thermal Conductivity Values Used

- Three different materials considered:
  - **Cladding Oxide:** The corrosion product caused by oxidation of the cladding, either during normal operation or after the LOCA
  - **Crud:** The deposits on the fuel before the LOCA
  - **LOCA Scale:** Deposits formed on cladding by deposition of corrosion products and scale after the LOCA

Clad Oxide Thermal Conductivity

- Cladding Oxide is primarily the reduction of zirconium cladding with oxygen; ZrO_2
- The most definitive thermal conductivity measurements were performed at Halden and are reported in WCAP-15063-P-A and EPRI TR-107718-P1 and P2
- Parametric Clad Heat-up Calculation
  - A value of 2.20 W/m-K (1.27 BTU/(hr-ft-°F)
  - Provides maximum rod heat-up calculations
- LOCADM Deposition Calculation
  - A value of 2.79 W/m-K (1.61 BTU/(hr-ft-°F) was used in scale build-up calculations
  - Reported in WCAP-15063-P-A (2000)

Crud Thermal Conductivity

- Crud is typically composed of nickel ferrite, nickel metal, nickel oxide and nickel-iron-chromium spinels
- Crud thermal conductivity is dependent on many variables such as porosity, thickness, and heat flux
- For fuel rod heat-up calculations
  - A value of 0.5 W/m-K (0.3 BTU/hr-ft-°F) was used

LOCA Scale Thermal Conductivity

- LOCA Scale
  - Likely to be rich in calcium at many plants
  - Literature searched for bounding value for boiler scale deposits
- Limiting value from data research is 0.2 W/m-K (0.11 BTU/hr-ft-°F)
- The limiting value is recommended for industry use in scale build-up calculations (LOCADM)
- A parametric study with thermal conductivity values from 0.17 to 1.5 W/m-K (0.1 to 0.9 BTU/hr-ft-°F) was performed in the rod heat-up and the grid study

Variability in Scale Thermal Conductivity

sodium aluminium silicate	0.2 - 0.4 W/mK
milk components	0.5 - 0.7 W/mK
hematite (boiler deposit)	0.6 W/mK
biofilm	0.7 W/mK
calcium sulphate (boiler)	0.8 - 2.2 W/mK
calcite (boiler deposit)	0.9 W/mK
serpentine (boiler deposit)	1.0 W/mK
gypsum (boiler deposit)	1.3 W/mK
calcium sulphate	2.3 W/mK
magnesium phosphate	2.3 W/mK
calcium phosphate	2.6 W/mK
calcium carbonate	2.9 W/mK
magnetite iron oxide	2.9 W/mK

From:
Hans Muller-Steinhagen, "Heat Exchanger Fouling- Mitigation and Cleaning Technologies" (Institution of Chemical Engineers, Rugby, UK, 2000) p .4

Collection of Material on Fuel Clad

- Three categories of protective coatings used inside containment have been evaluated to have no effect on the generation of precipitate
- Protective coatings used inside a PWR containment will not adhere to clad surface due to low temperatures
  - Zinc
  - Epoxies
  - Other

Boric Acid Dilution

- As noted previously, blockage of the core will not occur
  - Mixing volumes assumed for the current licensing basis boric acid dilution evaluations are not affected by debris and chemical products transported into the RCS and the core by recirculating coolant from the containment sump
  - Therefore, current accepted licensing calculations that demonstrate appropriate boric acid dilution to preclude boric acid precipitation remain valid

Upper Plenum Injection Plants

- Westinghouse 2-loop PWRs incorporate Upper Plenum Injection (UPI) as part of their ECC system
- UPI provides flow to the upper plenum continuously once the ECC is actuated
- For cold leg breaks
  - The UPI flow must flow though the core and out the break
  - Only a complete blockage would prevent sufficient flow to prevent core cooling
  - This flow also maintains core dilution, keeps boric acid and chemicals dissolved in the coolant from accumulating in the core

Upper Plenum Injection Plants

- For hot leg breaks, the upper plenum will be well mixed with approximately 1000 gpm flow circulating in the upper plenum and going out the break
  - Some flow will enter the core region while a majority of flow will go directly out the break
  - Debris accumulation in the upper plenum and upper fuel region will be minimal since debris will be carried out the break with the excess ECCS flow

Upper Plenum Injection Plants

- At the time of switchover for either the cold- or hot-leg break, the core is completely quenched and the clad temperatures are at or near saturation
  - Only limited subcooled boiling in the core is expected as coolant is recirculated from the reactor containment building sump
  - This limits deposition by boiling

Summary

- Adequate flow maintained to remove decay heat even with debris in coolant reaching RCS core
- Decay heat will continue to be removed even with debris collection at the fuel assembly spacer grids
- Fibrous debris, should it enter the core region, will not tightly adhere to the surface of fuel cladding
- Using an extension of the chemical effects method developed in WCAP-16530-NP-A, spreadsheet developed to predict chemical deposition
- As blockage of the core will not occur, the mixing volumes assumed for the current licensing basis boric acid dilution evaluations are not affected by debris and chemical products transported into the RCS and the core

Defense In Depth Calculations Long-Term Core Cooling to Support GSI-191

Defense In Depth Calculations

- These calculations performed to demonstrate defense in depth
- Extreme cases
- Two calculations performed
  - Blockage at core inlet
  - Local fuel rod blockage

Core Blockage Evaluation

- A blockage of about 99.4% of the core inlet area was evaluated
- The evaluation demonstrated that negligible impact on clad temperature would be expected due to blockage alone.

Problem Statement

- For a Double-Ended Guillotine Break, RWST can be Depleted and Sump Recirculation Begun Within ~ 20 Minutes
- Fibrous Debris and Particulates Can Pass Through Sump Screen
- Potential for Build-up at Core Inlet
  - Fuel assembly bottom nozzle, debris filter, grids
  - In the limit, collection of fibrous and particulate debris might cause high head loss

Selection of Limiting Break

Double-Ended Cold Leg

- Spilling of ECCS to containment
- Gravity head to loop level only
  - True for no single failure also
- Lower flow results in slower debris build-up

Double-Ended Hot Leg

- No spilling of ECCS
- Additional driving head from liquid level SGs
  - more for no single failure
- Higher flow results in faster build-up

Use Double-Ended Cold Leg Break With No Delay in Debris Build-up

Vessel Design Considerations (W OEM)

- Plants With ECCS Delivered to Cold/Hot Legs
  - Designed Upflow is Least Limiting
    - Numerous large pressure relief holes in baffle wall allow flow to bypass core inlet if blocked
  - Converted Upflow is More Limiting
    - No pressure relief holes, limited flow to top of core (if any)
  - Downflow is Most Limiting
    - Flow must enter core through lower core plate
- Upper Plenum Injection Plants also Evaluated

Other PWR Vessel Designs

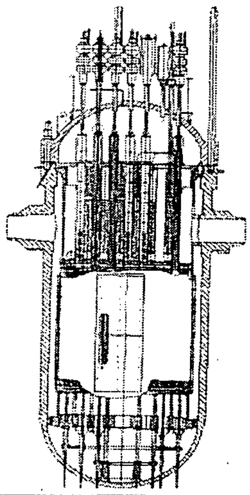
- B&W Design Similar to W Designed Upflow
  - Numerous large pressure relief holes in baffle wall allow flow to bypass core inlet if blocked
  - Barrel vent valves located above loop level
    - No impact on this issue
- CE Design Similar to W Converted Upflow No pressure relief holes, limited flow to top of core (if any)

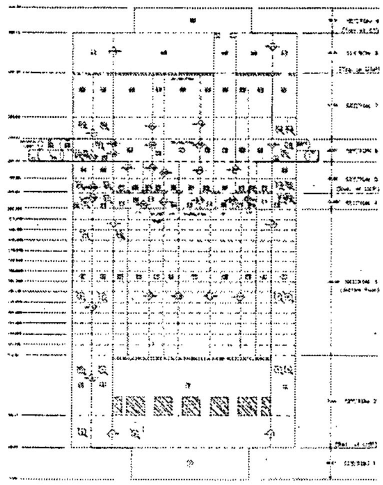
W Downflow Design is Bounding

Plant Selection

- Downflow Most Limiting Configuration
- Core Power Density Also Important for Heat Removal
  - Use available 3-loop downflow model for plant rated at 2900 MWt

Vessel Sketch and Node Diagram





WCOBRA/TRAC Modeling Approach

- Run Problem from Break Initiation
  - Create Single Use code version which ramps in high resistance as specified by User
  - Ramp in large increase in resistance at core inlet of PWR model
    - 1st node of core channels

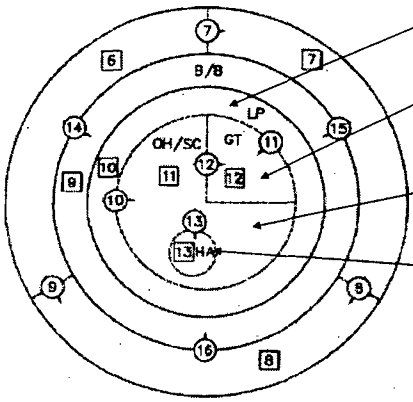
WCOBRA/TRAC Modeling Approach cont.

- Blockage Cases Run to 40 Minutes
  - Blockage ramped in from 20 to 20.5 minutes
  - $K = 10^9$ simulates complete channel blockage
- Increased injection temperature
  - Modeled at 20 minutes
  - Temperature ≈ RHR heat exchanger outlet
    - 190°F injection temperature used
    - Current LOCA M&E analysis uses 180°F

WCOBRA/TRAC Modeling Approach cont.

- Two simulation cases performed
  - 82% blockage, K ramped in all core channels except Lower Power periphery channel
  - 99.4% blockage, K ramped in all core channels except one assembly

Standard Core Modeling



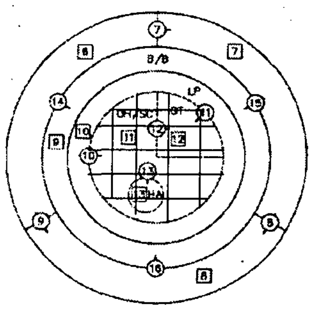
Peripheral Assemblies (28)

Interior Assemblies Under Guide Tubes (53)

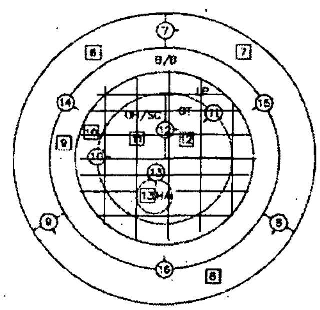
Interior Assemblies Under Other Structures (75)

One Assembly Under a Restricted Structure (1)

Blockage Approaches



Block All Except Peripheral (82%)

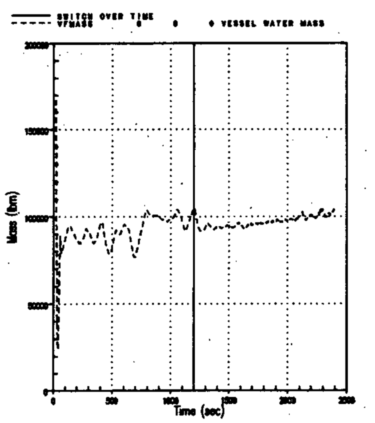


Block All Except One Assembly (99.4%)

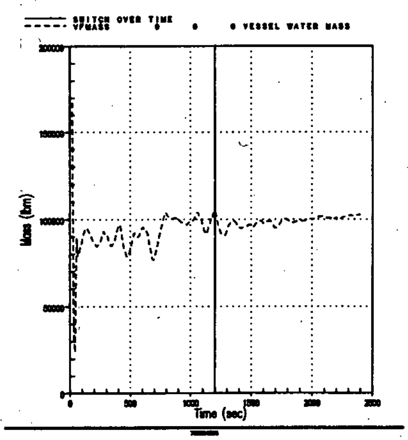
WCOBRA/TRAC Modeling Approach cont.

- Containment pressure at atmospheric conditions by switchover to sump recirculation
  - Extrapolated pressure vs. time table used in BELOCA analysis

Total Vessel Mass

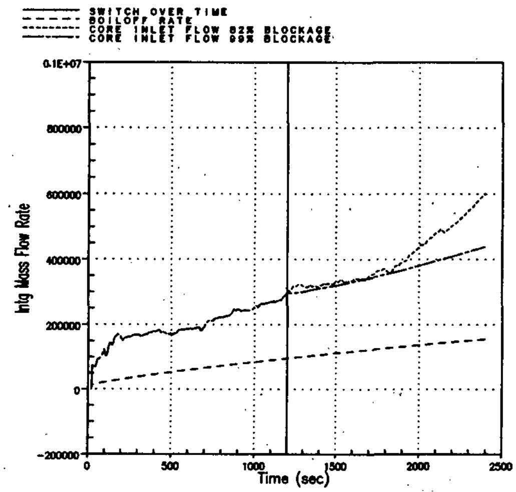


82% Blockage



99.4% Blockage

Core Flow Rate vs. Boiloff Rate



Summary of Blockage Calculations

- Flow diversion into unblocked channels observed in calculations
- Core flow rate > boil-off rate after blockage occurs
  - Difference in core flow between 82% and 99.4% blockage due to difference in resistance at core inlet
- Increase observed in predictions of
  - Core collapsed liquid level, and,
  - Total core mass

Local Blockage and Plate-Out

- Two phenomena studied parametrically:
  - Reduction of flow at a fuel grid,
  - Precipitation of chemical product on the surface of fuel cladding was evaluated
- A range of thermal conductivities for the precipitation were considered
  - Maximum value = 0.9 Btu/(hr-ft-°F)
  - Minimum value = 0.1 Btu/(hr-ft-°F)
- For all cases, over the range of conditions considered, the cladding surface temperature was evaluated to be below 800°F

Summary of Fuel Rod

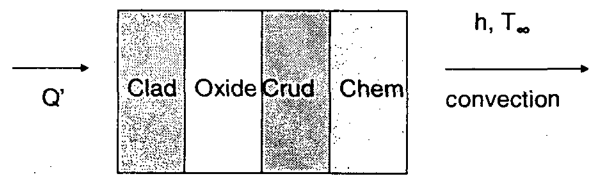
rod length (in)	144
rod outside diameter (in)	0.36
clad thickness (in)	0.0225

Variable Values

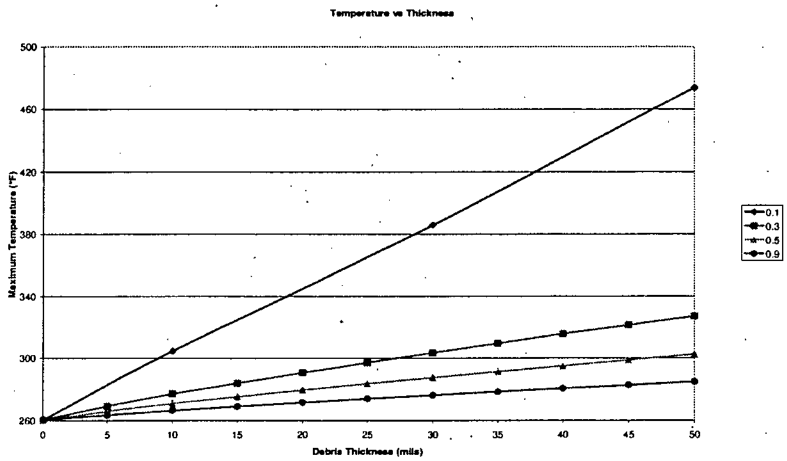
- Crud Thickness
  - 0.000 – 0.050 in
- Crud Thermal Conductivity
  - 0.3 – 0.9 BTU/(hr*ft*°F)

Model and Assumptions

- Steady-State, no Axial Conduction
- Uniform layer thicknesses (except chem.)
- Acceptance Criteria
  - Clad/Oxide interface < 800°F



Clad-Oxide Temp vs. Precip Thickness



Summary

- Information and evaluations performed demonstrate sufficient long-term core cooling achieved for PWRs to satisfy requirements of 10 CFR 50.46 with debris and chemical products that might be transported to the reactor vessel and core by the coolant recirculating from the containment sump
  - Blockage at the core inlet (top or bottom) does not occur
  - Fibrous debris is small in volume and dimension
  - Defense in depth analysis demonstrates that if a large blockage occurs, core decay heat removal will continue
    - Collection of debris on fuel grids
    - Collection of material on fuel cladding
- When considered collectively, 10 CFR50.46 long-term core cooling criteria satisfied

Conclusion

- Any blockage at the core inlet and outlet that may form will be limited in length and not impenetrable to flow
- Collection of debris on fuel grids Information and evaluations demonstrate long-term core cooling for all plants
- Test data demonstrates any debris that bypasses the sump is small
  - Geometrically
  - Volumetrically
  - Therefore not likely to collect on grids
- For defense in depth, numerical and first principle analyses demonstrate demonstrate that core decay heat removal will continue with complete local fuel grid blockage

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Protecting People and the Environment

Status and Path Forward for Generic Safety Issue 191, Pressurized Water Reactor Sump Performance

Presented by:
Michael Scott
Office of Nuclear Reactor Regulation

Presented to:
Advisory Committee on Reactor Safeguards
Thermal-hydraulics Subcommittee
March 19, 2008

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Background

- Generic Safety Issue 191 involves performance of PWR emergency core cooling and containment spray systems in recirculation mode in the presence of debris after a loss-of-coolant accident/high-energy line break
- Generic Letter 2004-02 requested licensees, by end of 2007, to:
  - Determine plant-specific debris generation and transport
  - Make needed modifications to show compliance with regulations in presence of plant-specific debris loading

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Current Status of GSI-191

- Essentially all PWRs have installed much larger sump strainers
- Staff and industry believe risk of strainer clogging reduced significantly
  - Significant uncertainties regarding debris generation, transport, and behavior at the strainer
  - Plants can continue to operate safely for same reasons as stated in GL 2004-02
- Integrated head loss testing (including chemicals) ongoing
  - Staff reviewing and commenting on protocols
  - Staff observing and commenting on representative tests intended to show adequate strainer function

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Current Status (Continued)

- Nine site audits of corrective actions complete or nearly so
- Results:
  - Licensees generally following staff-approved guidance for evaluating debris issues
  - Conclusions and assumptions not always well supported in documentation
  - Chemical effects and downstream effects analyses generally incomplete
- Desirable to conduct additional limited-scope audits in 2008 to obtain additional assurance in chemical and downstream effects

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Current Status (Continued)

- Most licensees received additional time beyond 12/31/07 to complete certain corrective actions
  - Downstream effects analyses
  - Integrated head loss testing
  - Plant modifications
- Most extensions for a few months; a couple into 2009
- All plants submitted supplemental responses to GL 2004-02 in February/March 2008

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Chemical Effects

- Many plants did not complete integrated head loss testing with chemical effects by end of 2007
- Completion delayed by:
  - Late recognition by industry of difficulty of the issue
  - Limited number of testing vendors, requiring queuing
  - Challenges resolving staff issues with chemical effects topical report
  - Staff issues with testing methods used or planned by test vendors
- Staff issued safety evaluation (SE) on chemical effects topical report in December 2007

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Chemical Effects Peer Review

- Staff screened peer review issues in 2007 to identify those warranting further evaluation
- Office of Nuclear Regulatory Research commissioned study of aspects that earlier staff review could not disposition
- Staff currently reviewing study results
- Likely result is need for additional confirmatory work in some areas
- Will report to Committee on this later in 2008

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Downstream Effects

- Ex-vessel (pumps, valves, etc.)
  - SE on ex-vessel downstream effects topical report issued December 2007
  - Some licensees have requested extensions to complete these analyses
- In-vessel (core flow blockage)
  - Received topical report June 2007
  - Draft SE issued in March 2008
  - Subject of today's meeting

Coatings

- Staff has reviewed several industry technical reports on coatings and has accepted certain methods and refinements proposed
- Staff has issued review guidance on coatings
- Licensees currently have enough information/guidance to address coatings issues

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Head Loss Testing

- Staff has questioned whether various aspects of the licensee-sponsored vendor-performed head loss testing are conservative or prototypical
  - Debris preparation
  - Near-field settling
  - Thin bed testing
- Staff's questions and concerns have had impacts on licensee test schedules
- Licensees can use any approach that they can show to be conservative or prototypical

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Head Loss Testing (Cont'd)

- One recent test of a uniform flow strainer conducted by adding full particulate load followed by sufficient fine fiber (only) to create a thin debris bed resulted in high head loss without chemicals
- Implications for other designs and plant-specific conditions under review
- Challenge for licensees is to develop conservative or prototypical, but not excessively conservative, test protocol

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GL Supplemental Response Reviews

- Staff has begun review of supplemental GL responses
- Time frame – March through October 2008
- Because of extensions, many licensees will need to submit an additional response

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Closing GL 2004-02 and GSI-191

- Staff plans to close these issues for each plant based on:
  - Review of licensee supplemental responses
  - Results of Region inspections of licensee corrective actions
  - Review of licensee responses to audit open items (as applicable)
- If a plant has not completed all modifications but has a satisfactory strainer evaluation in place and a specific plan for completing remaining modifications, staff plans to close the GL and GSI for that plant
- Staff will track all corrective actions to completion at all plants

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GSI-191 Time Line

- March/April 2008 – ACRS review of SE for in-vessel downstream effects
- April 2008 – Final SE for in-vessel downstream effects issued
- April – June 2008 – Limited-scope audits (chemical effects/in-vessel downstream effects) at selected plants
- June 2008 – Region inspections of licensee actions complete
- Summer 2008 (TBD) ACRS review of testing and other closure activities
- August 2008 – Reports of inspection results due to NRR
- October 2008 – Reviews of final supplemental responses to GL complete
- November 2008 – Issuance of closeout letters to licensees complete
- December 2008 – Management concurrence on closeout of GL 2004-02 and GSI-191

Proposed Subjects for Summer 2008 ACRS Review

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- Integrated head loss testing protocols and results
- Results of staff review of licensee supplemental responses
- Results of staff review of chemical effects peer review
- Results of additional confirmatory chemical effects testing at Argonne National Laboratory
- Other subjects of interest to Committee as identified
- Plan to seek letter regarding readiness for issue closure if warranted

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Disparities in Treatment for PWRs and BWRs

- BWR strainer issues resolved in 1990s
- For various reasons, treatment of debris-induced clogging issues has varied for PWRs and BWRs
  - Different strainer, ECCS, and core designs
  - Issues addressed at different times and based on different states of knowledge
- Learned a lot from PWR work – applicable to BWRs?
- NRR has sent User Need to ask RES to evaluate differences and recommend additional actions if warranted
- Encouraging BWR Owners Group to take initiative to address potential issues
- Considering further actions

Conclusions

- Licensees have made substantial progress in reducing vulnerability to strainer clogging and related issues
- Staff still expects issue resolution in 2008 but number of questions still unresolved will pose a significant challenge to that goal