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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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THERMAL-HYDRAULIC PHENOMENA SUBCOMMITTEE

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OPEN SESSION

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TUESDAY

OCTOBER 20, 2015

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 8:30 a.m., Sanjoy Banerjee, Chairman, presiding.

COMMITTEE MEMBERS:

SANJOY BANERJEE, Chairman

HAROLD B. RAY, Member

JOY REMPE, Member

STEPHEN P. SCHULTZ, Member

DESIGNATED FEDERAL OFFICIAL:

WEIDONG WANG

ALSO PRESENT:

JEFF BROWN, PWROG

ART BYERS, Westinghouse

KEVIN KAMPS, Beyond Nuclear

MICHAEL KEEGAN, Don't Waste Michigan *

MARVIN LEWIS *

MARK MUHICH, Sierra Club of Michigan *

JONATHAN ROWLEY, NRC

STEVE SMITH, NRC

JAMES SPRING, Westinghouse

GORDON WISSINGER, AREVA

*Present via telephone

T-A-B-L-E O-F C-O-N-T-E-N-T-S

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

8:32 a.m.

CHAIRMAN BANERJEE: The meeting will now come to order. This is a meeting of the Thermal-Hydraulic Phenomena Subcommittee, a standing committee or subcommittee of the Advisory Committee on Reactor Safeguards.

I'm Sanjoy Banerjee, the Chairman of the Thermal-Hydraulic Phenomena Subcommittee. ACRS members in attendance are Joy Rempe, Steve Schultz, and I think Harold Ray. Mike Corradini is traveling and I don't know if he'll be calling in or not. And John Stetkar will be in and out of the meeting.

Weidong Wang of the ACRS staff is the designated federal official for this meeting.

In this meeting the Subcommittee will review a Westinghouse Topical Report, WCAP 1778P, Comprehensive Analysis and Test Program for GSI-191 Closure, (PA-SEE-1090). We will hear presentations from the NRC staff and the representatives from industry. We have received a few requests for time to make oral statements from members of the public regarding today's meeting. We will take these before we go into closed session around 9:30.

Part of the presentations by the industry and the NRC staff will be closed in order to discuss information that is proprietary to Westinghouse and its contractors pursuant to 5 USC 552(b)(C)(4).

Attendance at these portions of the meeting that deal with such information will be limited to the NRC staff and its consultants, Westinghouse and those individuals and organizations who have entered into an appropriate confidentiality agreement with them. Consequently, we need to confirm that we will have only eligible observers and participants in the room for the closed portion of the meeting.

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*.

A transcript of the meeting is being kept and will be made available as stated in the

Federal Register notice, therefore we request that participants in this meeting use the microphones located throughout the meeting room when addressing the Subcommittee. The participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard.

We will now proceed with the meeting, and I guess I'll call on the staff, Jonathan Rowley, to kick this meeting off. Thank you.

MR. ROWLEY: Thank you, Mr. Banerjee. Appreciate it. My name is Jonathan Rowley. I'm the project manager for the PWR Owners Group tasks that come into the NRC.

The reason that the NRC wanted to come before the ACRS today was to gain insight and feedback on the methodologies proposed in WCAP-17788 and to get feedback early in our review for review efficiency.

WCAP-17788 came into the NRC on July 30th, 2015. The acceptance review is still pending. We are awaiting supplemental information from the PWR Owners Group for justification of cold leg break fibrous debris limit as defined in Volume 3 of the WCAP. Right now the owners group is scheduled to provide that information on November 30th of this year, and at that time we will make our acceptance review determination and proceed with the review if we deem the information adequate.

On October the 5th the staff did have an audit of the information that the owners group had ready at the time. They were still working on it, so what they had available, they showed it to us and gave us a good feeling that they were heading in the right direction to provide us information we needed and that we could accept the topical report for review.

MEMBER SCHULTZ: Did that audit focus specifically on the additional information?

MR. ROWLEY: Correct.

MEMBER SCHULTZ: Thank you.

MR. ROWLEY: All right. Our review schedule. If we do accept the topical report for review, is that on January 29th of 2016 we'll have some requests for additional information that we will submit to the owners group, wait to get those back and hopefully if everything is adequate we will provide our draft safety evaluation by July 1st of next year. And then we'll get their comments back on the draft safety evaluation from the owners group, resolve those comments and we're scheduled to issue our final SE by September of 2016.

The owners group has -- this is the first time they are aware of these dates because we have not accepted the topical report just yet, and so therefore we have not given them their acceptance letter, which this information would be contained in. So this is new to the owners group, but if everything goes according to plan, this is what we proposed to meet.

CHAIRMAN BANERJEE: So when would you expect to come to the ACRS, and would you request Full Committee letter?

MR. ROWLEY: I assume so that we would. We have to work it into this schedule. This schedule you see before you does not include any ACRS time of ACRS' required and needed and we'll have to adjust accordingly. But we'll try to fit it into these days, I think we can, as ACRS' schedule.

CHAIRMAN BANERJEE: Well, I think we should determine our schedule and get it at least tentatively put into our agendas.

MR. ROWLEY: That's all we have for the opening for the NRC, just a quick overview of where we stand at this point.

CHAIRMAN BANERJEE: Thank you. And I think now we can hand it over to the PWR Owners Group, if there are no other staff remarks. So, why don't we do that. And who will -- Jeff?

MR. BROWN: Yes.

CHAIRMAN BANERJEE: Okay. Go ahead.

MR. BROWN: Good morning. I'm Jeff Brown with Arizona Public Service and I'm here on behalf of the Pressurized Water Reactor Owners Group. As we've already discussed, we're going to be talking about WCAP-17788. This program was developed to establish a new approach for establishing in-vessel debris acceptable values for ultimate closure of NRC Generic Letter 2004-02.

What we're here to do really is to explain the reason why we needed to proceed with a new program and then to focus really on what the technical elements are of the program and what we're expecting in the way of results. We're really here just to share information with you now. We're not asking for or soliciting any particular feedback, although I suspect we may get some, but anything that we do receive will be greatly appreciated.

To the point that Jonathan made earlier, we would hope that this discussion would help facilitate a better exchange or at least simplify the process once we're back here before you in the review for the safety evaluation.

Next slide. Okay. So a little bit of the history of the owners group program and fiber limits. As you're aware, WCAP-16793, Revision 2 was submitted and approved. And that WCAP documented an in-vessel fiber limits evaluation. That approach was based on a bounding parametric type of an approach which enveloped all plants and established a single criterion that was applicable to all the facilities. The technical approach in 16793 was really to simply determine a fiber quantity that would establish the maximum permissible head loss while still ensuring sufficient long-term core cooling. Again, it was a bounding evaluation, produced one value and all plants have to live within that value.

So, that program again was based on putting all utilities into one box. It did not perform anything in the way of a formal design of experiment. And the testing that was completed really provided for a very limited understanding of the underlying phenomena. Nevertheless, the way that the program was constructed it was very conservative. And based on the inherent conservatisms the NRC approved that WCAP back in 2013.

Next slide. All right. So, the fact that the WCAP-16793 provided such a conservative value that was applicable to all the utilities motivated the owners group to proceed with another program. And as you're aware, 16793 produced that single criterion of 15 grams per fuel assembly, which only about a third of the utilities found that to be acceptable. Most plants were above that fiber limit. In fact, a number of plants; speaking personally from my plant, even though we are within that acceptance criteria, it leaves us very little design margin.

So coupled with the fact that the value is so restrictive leaves little margin and the fact that the program was developed in a very bounding and conservative way suggests that there are analytic margins that we could use to improve upon the limits. And this was the basis for why we wanted to proceed with another program. Based on those issues the PWROG Executive Committee directed that an industry advisory group or a tiger team be assembled to work with the technical folks to establish a program to improve upon the degree limits by recovering some of the analytic margin.

Next slide. So in 2012 a new program was initiated. Obviously, the objective was to establish increased in-vessel fiber limits while demonstrating long-term core cooling. This tiger team or the technical team required that the program establish a phenomenological understanding of the process, and particularly the fiber beds and the fiber beds associated or correlated with head loss. Also it required that we consider process timing including timing associated with core blockage and included some consideration of the timing of chemical effects.

The team also required that we needed to structure the program more as a traditional research type of an approach with the necessary development, appropriate literature review and to include a design of experiment.

So, from the beginning the program had a significant amount of input and oversight. Just briefly, some of the more important items that helped shape the program included an expert panel convened to develop a PIRT to initially inform the development of the program. We also consulted with outside vendors to perform an independent third-party review of WCAP-16793 to assess that effort and glean what we could for lessons learned to inform the new program. We also considered the input that we received from the ACRS on the WCAP-16793. The program was also informed by the risk-informed efforts from South Texas Project. And we also convened an expert review panel. Once WCAP-17788 had taken shape we wanted to make sure that we were going to achieve our end objectives and that we were covering all of the necessary technical items. And lastly, we've had a lot of interaction with the Nuclear Regulatory Commission. We've had several meetings and discussions and we have also had the staff out visiting our testing facilities in Pennsylvania to witness what we're doing and to see the results of the testing first hand.

CHAIRMAN BANERJEE: Did you change your water to other than Pennsylvania water sometimes to New Jersey water?

MR. BROWN: Yes, we'll get into that in just a few minutes. Basically we used demineralized water as our water source. Is that correct?

MR. SPRING: Yes, this is James Spring. We started with DI water and used prototypic coolants, so boric acid with various buffering agents in our head loss testing. So we will get into that as part of the closed session this morning.

CHAIRMAN BANERJEE: Just information of what you did.

MR. BROWN: Okay. Again, not to belabor the point, there were significant inputs and a lot of program collaboration in the development and execution of our program.

Next slide. And then lastly we have an overview of the program organization. And what you're going to be hearing during the balance of today's presentations will describe the technical pieces of this new program. The technical representatives are going to explain that the overall program evaluates two limiting scenarios: large hot leg breaks and large cold leg breaks.

The large hot leg break evaluation is

based on thermal-hydraulic analyses that use approved codes and takes advantage of alternate flow paths that provide core cooling in the event of total core blockage. The hot leg break thermal analyses are informed by scaled head loss testing and chemical effects testing, and we'll spend a great deal of timing going through the details of those programs a little bit later.

Now, a separate approach was taken for the cold leg break case, and that methodology is dependent upon work completed under the subscale brine testing; we'll discuss that as well, in addition to some other information that helps establish a conservative basis for the limits selected for that program. In the end or in total utilities will establish plant-specific in-vessel fiber limits based on the conclusion of both of those analyses and the subsequently results.

So, the results of this --

CHAIRMAN BANERJEE: It would be based on plant-specific analysis, right?

MR. BROWN: That's correct.

CHAIRMAN BANERJEE: You wouldn't do any plant-specific testing?

MR. BROWN: We did not do plant-specific testing. What we'll discuss as part of the chemical effects testing is we found that -- and I guess we should save this for closed session, but we did find that there was enough diversity among all of the plant groups that we had selected that we almost had to do plant-specific testing for that particular part of the program.

CHAIRMAN BANERJEE: Okay. We'll clarify that later.

MR. BROWN: Okay. So again, the results of this effort are documented in WCAP-17788. There are six volumes, and Gordon Wissinger will explain briefly on what's contained in each of those six volumes. Again, and to the point that you just made, this is a methodology that we applied on a plant-hospital basis as opposed to one value that applies to all plants. So, by establishing a methodology based on plant-specific inputs, analytic margin is available to support substantially higher values as opposed to the single value that was conservatively defined by WCAP-16793.

That's an overview. Are there any other questions?

CHAIRMAN BANERJEE: This is a WCAP but

you have AREVA talking about it? I thought you guys did separate testing?

MR. WISSINGER: I gets more entertaining than that, yes. So, there's proprietary information to both Westinghouse and AREVA in this report.

CHAIRMAN BANERJEE: And you'll actually share this information?

MR. WISSINGER: With the appropriate protections, yes.

CHAIRMAN BANERJEE: All right.

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: Maybe you should do that in some other fields.

MR. WISSINGER: We'll see how this one plays out. So far this project --

CHAIRMAN BANERJEE: I have one in particular in mind.

MR. WISSINGER: Okay.

CHAIRMAN BANERJEE: And it's not with Westinghouse.

MR. WISSINGER: I was going to say do I need to take it back? All right. Excellent. We'll talk afterwards.

CHAIRMAN BANERJEE: Yes, it's a

different plant.

MR. WISSINGER: Okay. So, my name is Gordon Wissinger. I represent AREVA. I've been on the project for quite awhile, including 16793. So, I want to spend a bit of time in the open session really giving an overview of what this report will have in it and then kind of lay the work for the details that we're going to get to when we get into the specific analysis.

So, Volume 1, as Dr. Banerjee has identified, is provide the methodology. We don't provide any limits, any final numbers, but we provide a methodology for plants to be able to use, apply their plant-specific inputs to come up with a number for their plant. This is applicable to all U.S. PWRs that are currently in operation and it includes considerations for the fuel vendor, the NSSS design, plant-specific design inputs and operating conditions. And we'll go through how all that fits together as we go through the presentation.

As Jeff alluded to this earlier, there are six volumes. Volume 1, which isn't listed here because I'm going to go through a little more detail, is the overview that ties everything together. It pulls from Volume 2, which is the PIRT, which is informed this early on. We're not going to talk in detail about that today. Volume 3 gives us a cold leg break evaluation methodology. It has its own separate volume because of the way these were conceived. The hot leg methodology is actually contained in Volume 1, so there's not a separate one for hot leg break. Volume 4 has detailed discussions of thermal hydraulic analyses, which we'll get into shortly. Volume 5 has the chemical effects, which Art Byers, Dr. Byers will be talking about today. And then Volume 6 has the subscale testing, which James Spring will be talking about later. So, this report presents the final results that the utilities can then use going forward.

So, the process looks a little bit like this. This is a very high-level flow chart. Plants will define very specific limited set of inputs they need to gather and then they'll calculate mass of fiber for both a cold leg break and for a hot leg break. One is not necessarily limiting compared to the other, but both of them have to meet their respective acceptance criterion.

This work is definitely a different

approach than what we've seen in 16793. It allows for increased limits and it also allows for some customization and some margin recovery for a number of plants. In the end we're certainly going to use this to close out GSI-191 and Generic Letter 2004-02.

You'll see this figure a little bit later today as we go through the various processes, but this is the flow chart again at a fairly high level of what the hot leg break looks like. The major components of the hot leg break include thermal hydraulic analyses to help us inform how the alternate flow paths -- and I'll get into what those are a little bit later. The chemical effects will define when we get chemical products. If you recall from 16793, when we got chemical products, we had very large head losses. So we're seeing if we can delay when the chemical effects arrive, take advantage of that. And then we also have much more detailed head loss testing. So we're looking at particulate and fibers. And we'll talk again in detail on those in the closed session.

So, you'll see this figure again and when we're highlighting which blocks we're actually going to be talking about. These all --

CHAIRMAN BANERJEE: K being the --

MR. WISSINGER: I'm sorry?

CHAIRMAN BANERJEE: -- loss factor?

MR. WISSINGER: Say again?

CHAIRMAN BANERJEE: K being a loss factor there?

MR. WISSINGER: Yes. So when we look at K, it's essentially a stand-in for the flow losses through a debris bed, in particular four or five or n particulates.

CHAIRMAN BANERJEE: So. I suppose this depends on the full regime whether the loss varies -- with velocity or not. So, does K become a function of velocity?

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: So it's not a constant?

MR. WISSINGER: I think that's true. We do have it varied across -- yes, James will get into a lot of the details of those, but it's not a -- we don't have a constant K loss. We define K loss as a function of fiber load which is determined from testing across a range of velocities that we looked at in the testing.

CHAIRMAN BANERJEE: So, basically you

have a correlation of some sort? Okay.

MR. WISSINGER: I'm going to let you answer that one. I'm not --

MR. SPRING: Yes, this is James Spring. What we do with the K is we simulate resistance at the core inlet in the T-H work using our system codes. So that K comes in in the velocity head, one-half rho Kv squared. And then in the subscale testing that's what gets us to a physical debris limit, a physical quantity of fiber. So, we take the results, the measured DP from the subscale testing. We relate that into a dimensionless K factor and then we compare that to what was simulated in the T-H work so that the pressure drop at the core inlet is preserved.

CHAIRMAN BANERJEE: Okay. We can get into it in more detail.

MR. SPRING: Yes, we'll get into that.

CHAIRMAN BANERJEE: Because if I remember from way back; and I don't think there's anything proprietary about this, one of the issues we had was in simulations how to treat this, because some computer programs like COBRA/TRAC or whatever you have to input certain K values and then do a parametric change in these to find if what you have is acceptable. But it's always the v-squared dependence that sort of bothered me because I don't understand really what the physics is here.

MR. SPRING: Yes, you would expect to see something more like traditional porous media factors.

CHAIRMAN BANERJEE: Oh, that would be v, right? So, it's somewhere in between the two?

MR. SPRING: Certainly.

CHAIRMAN BANERJEE: Yes. Okay. We'll revisit this. Go ahead.

MR. WISSINGER: So, yes, just to wrap this up, all of these inputs will then go into calculating the process for getting our final hot leg break debris limit. And we compare that to our acceptance criteria. If we meet it, then that fiber load is okay and we move on. If not, we have to refine the inputs, reduce the fiber load, etcetera, until we do get acceptable results. Similarly --

CHAIRMAN BANERJEE: Do you couple this to the strainer upstream in the sense that some stuff is getting through it, right?

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: And as you build up a fiber bed clearly this changes. May or may not. I don't know exactly. But let's say there are changes. So, are you trying to simulate this in time as well, or is it more like taking snapshots at various --

MR. WISSINGER: We are doing it in time. We do include a strainer efficiency in the process. So, we will look at the -- and I think this is probably not a big deal to talk about proprietary-wise, but we will look at the entire -- the containment is part of the solution. And we have a strainer efficiency as well as flow paths that will take debris and flow either to core inlets or back through the core containment sprays, etcetera.

CHAIRMAN BANERJEE: Yes, we can take it up, but basically you've got two major filters in the system.

MR. WISSINGER: Yes, and we do consider them in this evaluation.

CHAIRMAN BANERJEE: Yes, and they're coupled --

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: -- some ways?

MR. WISSINGER: Right, so it's decoupled in the sense that we take the debris generated and use that as a fixed input. So this is what a utility says. This is what I've generated with my ZOI evaluation. It's not coupled to that. I just have -- this is my worst debris load. I put that into the system. And, yes, I have a filter through the strainer and then I track where it goes through the containment spray into the vessel, whether it comes back out the break, what have you, and refilters, etcetera. So, yes, we do consider that for both the hot leg break and the cold leg break.

CHAIRMAN BANERJEE: And you do this in time?

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: Things evolve?

MR. WISSINGER: Yes, which means we have to look at variations in the ECCS flow rate, the delivery of the debris coming to the core. Yes, because what we find is -- and I'm kind of jumping ahead. Actually I am jumping ahead. I'll get to that --

CHAIRMAN BANERJEE: But I think it's

useful, because the methodology is really important.

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: And you can speak of that freely here, I think.

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: Yes.

MR. WISSINGER: No, I was -- two slides from now I actually get to that, but yes.

CHAIRMAN BANERJEE: Okay. If you wish, yes.

MR. WISSINGER: Yes. Okay. Just let me finish up with the cold leg and we'll get right into that exact question actually.

So, very briefly, similarly the cold leg has its own process. Same thing here, Dr. Banerjee, where we're going through and following where the debris goes in time. Okay? And this is described in detail starting in Section 4.3. We have other details in Volume 3 as I've identified.

Okay. So for the process I also want to lay some groundwork for what we're going to talk about later today. So this is kind of a broad picture of what we're actually going to talk about. I want to talk about the definition of what in-vessel debris means, and this is really the time dependency that we've just alluded to. I want to expand upon what Jeff has indicated about break scenarios. I want to explain why we're looking at what we're looking at. And then we want to look at the acceptance criteria. What is our benchmark?

Okay. So this is how we define in-vessel debris. And it's essentially the summation of what debris accumulates at the core inlet, what debris will go around the core inlet and reach the heated core itself and what debris may go out the break. The way these three parameters are defined depends on the break that we're looking at. So we'll kind of break this down for the mass at the core inlet.

For the hot leg break this is defined in part by the T-H analyses and in part by the subscale testing. So we're basically accumulating debris at the core inlet depending on the conditions. For a cold leg break anything that gets to the lower plenum will stay at the core inlet. That's the most limiting factor for that, so it all accumulates there at the core inlet if in fact it reaches the lower plenum.

We also consider mass in the core. So,

we've talked about alternate flow paths. I'll kind of give you a hint on that. It's a path that you block at the core inlet or you have a resistance at the core inlet that's big enough, you have other paths within the vessel wherein debris and fluid can go around that blockage and reach the heated core itself. This is something that has been neglected or was neglected in 16793 work. We're taking advantage of it at this point. So given that, we need to understand and what are the effects of how much debris or what debris gets to the core and what are the effects of that debris. So we will track that as well.

CHAIRMAN BANERJEE: Can you answer a high-level question here? When you look at these alternate flow paths, clearly debris is flowing in with the fluid.

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: And it will accumulate in the region of the flow paths.

MR. WISSINGER: Potentially, depending on the opening --

(Simultaneous speaking)

CHAIRMAN BANERJEE: Depending on the opening and depending on the fuel or whatever in that region. Did you do any experiments related to that?

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: Okay.

MR. WISSINGER: Yes, we will talk about that in the closed session as well. Yes, we do that actually in --

CHAIRMAN BANERJEE: Steve, you had a question?

MEMBER SCHULTZ: No.

CHAIRMAN BANERJEE: Okay.

MR. WISSINGER: We also have the potential that debris can exit the break as in not even reach the reactor vessel. We'll talk about the scenarios here in a minute. Just suffice it to say that for hot leg break we neglected this, any debris out the break, and the short answer is because debris has to go down the downcomer through the core before it can reach the break. So, we assume that any debris that gets into the lower plenum will be captured either at the core inlet or within the heated core itself. And then we take no credit for any debris overflow out the break.

Conversely, for the cold leg break ECCS comes in the cold leg right next to the break so we do take credit for that flow split. And I'll explain detail here in a minute what that looks like when I talk about the break scenarios that we examined. So, this really defines anything that gets in the debris. We don't take credit for any debris settling. We don't take credit for any debris getting help up anywhere except in either the heated core or at the core inlet.

So, let's talk about what break sizes we have to look at. A lot of questions on this in the past. We've looked at large breaks. The tiger team challenged us to define and defend. Is that really all we have to look at? Can you get a worse result with a smaller break? So we took a look.

The first aspect of this discussion is debris generation. And debris is generated based on the spherical zone of influence, so the bigger the break, the bigger the zone of influence. And in fact it will increase to the third power. So you see a curve on the screen that basically says as the pipe diameter increases you'll get tremendously more debris than you would for the much smaller break sizes. So, that's step one.

We couple with that --

CHAIRMAN BANERJEE: Because of the

model, right?

MR. WISSINGER: Say again?

CHAIRMAN BANERJEE: That's because of the model that you use, the zone of influence and the --

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: Is that borne out by experiments?

MR. WISSINGER: I cannot talk to that. I don't know.

CHAIRMAN BANERJEE: So that debris generation part of it is just taken from what we agreed to historically?

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: That's been fixed?

MR. WISSINGER: Yes. We also know based on some plant data that higher debris loads at the sump strainer ultimately lead to more debris getting through the sump strainer. And a fairly straightforward explanation. What we have here presented is a figure of the fraction of debris that penetrates the sump strainer for a given bed thickness. So, the amount of debris that actually gets through is the integral under this curve. So, if we get more debris or we have a little bit of debris, we'll get a relatively thinner bed, which means the integral under that curve is less than something that will generate more debris and a thicker bed. So at the end of the day we're pushing more debris into the RCS.

CHAIRMAN BANERJEE: So this must depend on the nature of the debris, right?

MR. WISSINGER: To some extent, but the tests that we have, the data that we have is not related. So, test 1, test 2, test 3, I don't have the details at hand, but it is my understanding that there's not just one debris type, that there's a mix of debris and that the results were fairly consistent based on that debris mix. So, it's not a function of debris --

(Simultaneous speaking)

CHAIRMAN BANERJEE: So, were these just replications to see how well you could replicate things, or did you actually change the composition of the debris in these tests?

MR. WISSINGER: My understanding is that the composition of the debris was changed throughout the tests and that the results were consistent along the line. We can certainly look into that a little further, but that's my understanding of that data.

CHAIRMAN BANERJEE: So if I had purely fibrous, largely fibrous debris coming into the strainers versus is when I had say particles and fibers and whatever, you'd get the same results based on thickness?

MR. WISSINGER: Certainly what we find is that in our tests as well as in the sump strainers fiber is the driving factor. Certainly particulates will fill in. But, yes, that is my understanding that you'll get a similar result for the fiber penetration, whether you have the fiber only, whether you have particulates and fiber.

CHAIRMAN BANERJEE: And does it depend on the nature of the strainer, or is it just independent?

MR. WISSINGER: That I don't know.

MEMBER SCHULTZ: How did the tests -- how were they derived or set up to meet up with a characterization of break size? They span the range of the chart there even though you showed small break, large break.

MR. WISSINGER: Right.

MEMBER SCHULTZ: Test 2, for example, goes across the whole range of bed thickness, so how did you make that transition or correlation between the break size and the test results?

MR. WISSINGER: Right. So, the correlation between the test size and the break result or the break size comes down to as you add in debris gradually throughout your taking data points. So, you can add X amount of debris in your sump, measure the thickness on your strainer, measure the bypass at that range. So you end up with a data point, a certain thickness and then how much of the fraction is coming through. And you continue to add debris into the sump itself. You're building that debris bed, and thicker. And again, you're measuring what's going downstream of that. So, it's not really correlated directly to break size, but when you look at -- back to bigger breaks generate bigger, more debris --

MEMBER SCHULTZ: The first chart, which was the zone of influence and --

MR. WISSINGER: Right.

MEMBER SCHULTZ: -- the amount of debris that could be characterized as associated with the break.

MR. WISSINGER: Correct. So this red line is more for illustration. It's not necessarily that a large break will generate a bed thickness of an inch-and-a-quarter. It may be something smaller for a given plant. But if you go to that same plant and you have a smaller break, it's certainly going to generate less debris, which means you're going to have a thinner bed.

MEMBER SCHULTZ: What are the differences between tests 1, 2 and 3? Are they just --

MR. WISSINGER: I don't have the details of it all.

MEMBER SCHULTZ: Okay.

MEMBER REMPE: Would you go back to that normalized debris generation versus break pipe diameter plot? This was just something that was agreed to in the past and there's no requirement for any sort of sensitivities or anything like that?

CHAIRMAN BANERJEE: I guess maybe you should ask staff this question.

MR. SMITH: Yes, this is Steve Smith. When we first started trying to resolve Generic Letter 2004-02, we came up with some simplified methods for debris generation and we agreed with -- basically NEI came up with guidance that they could use a spherical ZOI to estimate the amount of debris that would be generated from any break. And that's been accepted practice for the last 10 years.

MEMBER REMPE: And there was no testing done to support it? It was just simplified models?

MR. SMITH: It was a simplified model. I think the testing to validate that model would be difficult. And of course, it really depends how accurate that is. There is some inherent conservatism in that. And it's too bad Dr. Wallis isn't here. He could probably entertain us for the morning on why he agrees and disagrees with some of the estimations that are made by that model. But it certainly depends on how uniformly the various types of materials are spaced around the break and things like that. So, it's an estimation. It's not a precise value.

MEMBER REMPE: Okay. Thank you.

CHAIRMAN BANERJEE: I guess her question was do they look at the sensitivity to this input in the analysis. That's the question, right?

MEMBER REMPE: Yes, and it sounds like the answer is no, is what I'm guessing. It was just agreed to --

CHAIRMAN BANERJEE: Yes.

MEMBER REMPE: -- position.

CHAIRMAN BANERJEE: And if you go back in history, you'll see Graham Wallis and people who have many learned tomes of material on this, including similar stuff. But someway we have to close of something.

MR. SMITH: We have general agreement from the ACRS that it was an acceptable methodology.

CHAIRMAN BANERJEE: Yes.

MEMBER REMPE: Okay. Thank you.

CHAIRMAN BANERJEE: We've blessed it also.

(Laughter)

CHAIRMAN BANERJEE: This though I have several questions on. So, let's say that this is just a -- and I'm doing this in open session because I think it should be quite innocuous. In this testing was the velocity fixed, or did you allow the velocity to vary as the bed thickness built up, or how was this done?

MR. SMITH: Do you have any details on the tests, James?

MR. SPRING: Yes, we didn't come prepared to talk about this testing. It was not done as part of the program. It was done by member utilities that we drew from. So, I think the best I can do for you today; and I apologize for the -- is to take the questions and bring them back and --

(Simultaneous speaking)

CHAIRMAN BANERJEE: This is your source term for the --

MR. SPRING: Absolutely.

CHAIRMAN BANERJEE: Right?

MR. SPRING: Yes.

CHAIRMAN BANERJEE: So --

MR. SPRING: Yes, you're asking good questions, obviously.

CHAIRMAN BANERJEE: Right. But, okay. So we'll table it. And as this meeting is informational, it would be interesting to understand the -- so, this is sort of like what happens now in the second strainer? I've always been concerned that the two filters are very coupled. And I think Graham has been, too.

MR. SPRING: Yes.

CHAIRMAN BANERJEE: Right?

MR. WISSINGER: Are we good to go?

CHAIRMAN BANERJEE: Yes.

MR. WISSINGER: All right. So, the last bit of information that leads us to the large break is in fact the rate of the redelivery to the core. As the break size increases, the RCS depressurization is faster. You get to lower pressures. And as you get to lower pressures, you increase your ECCS flow. So, larger breaks depressurize more quickly. Since ECCS is a function of that pressure response and debris is delivered proportional to the ECCS flow, higher flow rates will deliver debris more quickly to the RCS, and that's more of a challenge to us because of the higher decay heat earlier in the transient.

So, when we put these three items together, we were convinced that large breaks bound small breaks. Because they generate more debris in the containment they allow more -- or more debris then ultimately gets through the sump strainer itself and we get that debris there sooner, which is more of a challenge to the decay heat removal.

CHAIRMAN BANERJEE: Now, with regard to the chemical effects do the large breaks lead to -- of course the transport of the materials would be faster, but would the chemical effects come in more rapidly for large breaks as well, or --

MR. WISSINGER: I'm going to say no and see if Dr. Byers is available to answer that question. I'm thinking --

CHAIRMAN BANERJEE: What's the rate determining step? That's what I would ask.

MR. WISSINGER: Yes, and I have to level the chemical effects to Dr. Byers on that. We can either get into it now or -- do you have a quick answer for that, Art?

CHAIRMAN BANERJEE: If there is nothing proprietary in the qualitative answer, it's better to do it in the open session.

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: So, we want to be as transparent as possible. If there's something madly proprietary, don't tell us then.

MR. BYERS: Art Byers, Westinghouse and the PWROG. Yes, certainly the larger breaks and generating more debris create a larger source term and higher temperatures in the sump, so we expect the chemical generation to be faster and a larger quantity.

CHAIRMAN BANERJEE: So that the flow rates and the temperatures and so on will affect the rate at which the chemicals will enter and go through the various reactions in the system. Is that the idea?

MR. BYERS: Well, I --

(Simultaneous speaking)

CHAIRMAN BANERJEE: -- determined step is not the dissolution of the chemicals?

MR. BYERS: Well, I think there's two different components. One is the actual entry of the debris into solution and the amount of debris. And then there's the flow rate itself and what effects that might have on the dissolution process.

CHAIRMAN BANERJEE: Do you actually model this in some detail or you take some bounding scenarios?

MR. BYERS: What we've been doing is taking a bounding amount of debris along with a representative amount of the flow. The tests that were done for chemical effects were stirred, but we didn't try and simulate the flow conditions exactly.

CHAIRMAN BANERJEE: Okay. So you took the test based on those sterile experiments and used that to get the chemical source terms?

MR. BYERS: Based on what experiments?

CHAIRMAN BANERJEE: The sterile experiments.

MR. BYERS: Oh, that's correct.

CHAIRMAN BANERJEE: Okay. I think that's sufficient for now. We'll get into chemical --

(Simultaneous speaking)

MR. WISSINGER: Yes. It's the last session I think of the day, but yes.

Okay. So having established the break size we know that large breaks can occur anywhere in the RCS piping. So we had to then look at can we do a single break size or do we -- or break location, or do we need to do multiple break locations? We came to the conclusion that we do need to look at both cold leg breaks and hot leg breaks because of the different system response between the two.

So, let's first look at the cold leg break scenario. This gets into a little bit more details about the methodology. So, as you can see here, I've got a representation of the system, what it looks like post-LOCA in the long term. At this point the downcomer has got some collapsed level to it. The core has got some boiling, so you've got some manometric difference between those two regions. The net flow into the core is only what is needed to make up for boil-off because the steam is leaving the top and going around the loops. So, you've got an excess of ECCS coming in the cold legs. It's keeping the downcomer liquid level full and replacing boil-off. So, you've got a considerable amount of fluid that's running out the break.

So, in that case you have a flow split where you've got some that can go back to the break, some that can go to the core itself. And so that's the cold leg break scenario. We're going to take that credit for it to go out the break and then return back to containment and be refiltered.

CHAIRMAN BANERJEE: So what goes out of the break? Let's say it contains some debris.

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: And that debris then recycles back to the upstream strainer?

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: And then does things to that?

MR. WISSINGER: And it is refiltered. So, you've gone some filtration efficiency at that strainer. So, you're going to then reintroduce some debris. It's going to come back and go through that same split process.

CHAIRMAN BANERJEE: So, the real issues becomes that filtration efficiency. The filtration efficiency was zero if it all passed through?

MR. WISSINGER: And it will all eventually get into the core.

CHAIRMAN BANERJEE: And will eventually all get to the core?

MR. WISSINGER: Yes. If it's 100 percent filtration, then nothing. So, yes, the challenge there is to defining what is your filtration -- what is the plant filtration efficiency? And that's one of the plant inputs. They do the testing to define what that looks like. Whether it's a boundingly constant value or whether it's a time-dependent value, that's up to them to them to define and defend. So it's an input to this process.

MEMBER SCHULTZ: Are you changing the amount of debris generated based upon the break location? You're saying, well, we had to determine whether we did break location analyses, but then you went quickly to large break or -- I mean, hot leg or cold leg.

MR. WISSINGER: Yes.

MEMBER SCHULTZ: But within that designation, cold leg breaks, the debris generation is the same for all cold leg breaks?

MR. WISSINGER: My understanding at this point; and I think this may be up to the utilities, it's something they can defend that there is -- from our perspective there is a single bounding debris generation. It is -- they have --

MEMBER SCHULTZ: For what you're calling a generic analysis, but you would allow for plant-specific analysis in some fashion to try to generate some display or --

MR. WISSINGER: Well, certainly -- yes, certainly --

MEMBER SCHULTZ: -- differentiation between break location of the cold break?

MR. WISSINGER: Yes. So, utilities will define a limiting break, whether it's in the cold leg break or the hot leg break. It's typically going to be in the hot leg break because they're bigger breaks and they generate more debris. Our expectation is that that debris generation from that hot leg break would then be applied to the cold leg break. They would not refine that necessarily, although there's no reason why they could not if they came into the staff and said we're doing a cold leg break analysis, therefore, we're going to use our worst cold leg break. We're doing a hot leg break analysis, therefore, we're going to do our worst hot leg. But right now we're assuming everybody is using the worst break wherever it is and applying it to both of these to do their downstream effects, in-vessel effects.

MEMBER SCHULTZ: But there is difference in debris generation, hot leg versus cold leg?

MR. WISSINGER: Possibly.

MEMBER SCHULTZ: Possibly?

MR. WISSINGER: Well, just from a high -- a large perspective and you're talking to a core guy, not a containment guy, the break sizes are different. Cold leg breaks are typically in the 24-inch range. Hot leg breaks are in the 36 or so.

MEMBER SCHULTZ: Understood.

MR. WISSINGER: But it all depends on where those pipes run within containment. And so, I can perfectly see that a cold leg break, even though it's smaller, could generate more debris because they've got it in a tighter containment or compartment somewhere or whatever. Our intent here is to say just what's your worst case and apply it to your in-vessel results.

MEMBER SCHULTZ: Okay. Thank you.

MR. WISSINGER: Compared to the hot leg break the schematic, or the system responses is a little different. In this situation the break is on the other side of the vessel. It's away from the SI injection or the ECCS injection, so fluid will come in the cold legs, fill a bit of the crossover piping until you get to a certain level and it can't go any higher than the break location. You'll fill the downcomer most likely. You'll still have boiling in the core, but you're essentially a single-pass filter and the debris and fluid will come in the cold legs, down the downcomer, up through the vessel heated region and then out the break.

So, in this scenario all of the debris will first approach the core inlet or the heated core before it has an opportunity to exit the break. So, we assume that it is collected within those two regions and that none gets through and exits the break. So, that's the biggest difference between these two is that cold leg break I've got a split, I allow some to go to containment and return. Hot leg break, it all actually approaches the core inlet and I have to decide where it goes based on the time and the flow and the conditions within, and nothing gets out the break.

So, having said all that, the evaluation is just a reiteration. This process will look at both large hot leg breaks and large cold leg breaks from an in-vessel perspective. And we have to show that both of them meet their respective acceptance criteria before they can show acceptable results.

So, how do we define what those acceptable results look like? We've established two criteria. These are very similar to what we had in 16793. The first is that decay heat removal requires that we have sufficient flow to the core to have the cladding remain at a acceptably low level. And in our case it's 800 degrees, which is previously defined and approved in 16793. So in short, we want to show that if we have any cladding heat-up for any situation that it remains below 800 degrees.

Our second criterion is to make sure that our boron concentration within the vessel itself does not build up such that we exceed the solubility limit.

CHAIRMAN BANERJEE: So going back to that criterion --

MR. WISSINGER: Yes.

CHAIRMAN BANERJEE: -- I mean, to some extent it depends how you interpret that, because does that mean that it should not reach at any point for any length of time, or are you interpreting that to mean the 800 degrees in a sustained manner?

MR. WISSINGER: Yes, well, what we have chosen to interpret that being as that at no time for any length of time shall the cladding temperature in any location in the core exceed 800 degrees, post-quench. So again, this is --

CHAIRMAN BANERJEE: You had a dry patch for example. That could be a transient effect; it comes and goes.

MR. WISSINGER: Correct, and we've not seen -- I mean, the conditions should be that that should stay below 800 degrees.

CHAIRMAN BANERJEE: Because I think

this is okay to say in a non-proprietary session, but that might be interpreted as some core exit quality, for example, that could lead to onset of dry-out. I'm trying to work my words very carefully. So for example, let's take a number, it could mean that at 50 percent core exit quality you might have a propensity for some regions to dry out. And if one gets into dry-out, then probably it would get up to these temperatures. And so there couldn't be like a core exit quality of one. It would come back down to about something like 50 percent or lower. So, it's a question of how you want to interpret this. You have to make it ultimately quantitative, right?

MR. WISSINGER: Correct. Where it's applicable, yes, we have to --

CHAIRMAN BANERJEE: Yes.

MR. WISSINGER: -- show that.

CHAIRMAN BANERJEE: So, I'd be interested to see --

MR. WISSINGER: I think we'll get into a little bit more of those details in closed session.

CHAIRMAN BANERJEE: And the reason I mention this of course is with one of the new reactors we went into a long debate about what this actually mean.

MR. WISSINGER: Okay.

CHAIRMAN BANERJEE: Go ahead.

MR. WISSINGER: All right. The second criterion, just kind of to get us back up here, or to reiterate, is to ensure that we do not approach the solubility, or we remain below the solubility limit, that core boron concentrations are not allowed to build up excessively. This has previously been a cold leg break issue. And in 16793 with such low fiber loads we felt that that was resolved. As we increase the fiber load, the question has come up again. And of course with hot leg breaks as you increase the fiber loads that question has come up. So, we will be addressing that as well. I'm sure that we do not exceed the solubility limit.

So, if we meet these two criteria, this is sufficient to demonstrate compliance with 10 CFR 50.46 for long-term core cooling. And the following presentations are essentially going to get into these details. We're going to expand upon the hot and cold leg break scenarios, how they are evaluated and demonstrate that the acceptance criteria are met, and we're going to discuss each volume pretty much in detail.

So, that's all I have for the open session. If there's any additional questions before we open it up to -- I understand there are some public comments that you wanted to be made.

CHAIRMAN BANERJEE: Yes. So, let me ask my colleagues if they have any questions at this point before we open it up.

(No audible response)

CHAIRMAN BANERJEE: Joy, you get a chance in the closed session, of course.

(Laughter)

CHAIRMAN BANERJEE: That's fine. So in that case, thank you very much for I think a informative open session. And I think we will now take public comments.

Weidong, is the line open?

MR. LEWIS: This is Marvin Lewis.

CHAIRMAN BANERJEE: Hi, Marvin. Thank you for attending this meeting. This is Sanjoy Banerjee. Please make your comments.

For all those who wish to make comments, we generally ask you to confine your comments to about five minutes. So, with that in mind, please organize your thoughts so we can have the comments in about that length of time.

So, Marvin, with that, please go ahead.

MR. LEWIS: I've always attempted to make comments short and sweet.

CHAIRMAN BANERJEE: Yes, I know.

MR. LEWIS: Maybe not so sweet. Okay. Anyway, look, 10 CFR 50.47, I think it is, a rule, just went through rulemaking. I don't know where it is exactly and I don't believe it's been accepted yet. However, what I'm thinking is that a lot of work went into 50.47 rulemaking and a lot of this work sounded very much like the work that you're doing for GSI-191. And I just wonder if you have incorporated the applicable parts of that rulemaking herein. Thank you. Bye.

CHAIRMAN BANERJEE: Thank you. We'll certainly take that comment seriously and take it into account.

Is there any other public comment? Anybody else wishes to speak?

MR. KEEGAN: Hello. Can you hear me?

CHAIRMAN BANERJEE: Yes, we certainly can. MR. KEEGAN: Yes, this is Michael Keegan with Don't Waste Michigan. I tuned into this case because I've been tracking the Palisades Nuclear Plant for a decade.

I sat in on an ACRS Subcommittee meeting on July 11th, 2006 where it was revealed that the screening on the sumps at the Palisades were very much inadequate, a total of 52 square foot. And when a member or the chair asked, well, what size should it be? Are we talking tenfold, a hundredfold, larger? And Palisades responded that they thought it needed to be eightyfold larger than what it was. Three thousand to five thousand square foot screen that they promised that they were going to put in place. And the members said, well, regardless whether you get the license renewal or not, you have to do that work. Well, what happened was they replaced the 52-foot square screen with a 52-foot square screen. And there was no follow up.

So, promises get made at these meetings and there's no follow up. As I've stated before, ACRS asks great questions and they accept lousy answers from the industry.

So, that's my question. I would like to refer the members back to the July 11th, 2006 transcript beginning at page 48. Take a look at that. Things are still unresolved. And those are all my comments for today. I will be reviewing the documents which I got late last night. So it's a bit tough to participate being left in the dark. So, thank you. Those are my comments.

CHAIRMAN BANERJEE: Thank you very much. Are there any other comments? Anybody else wishes to speak? Oh, excuse me. Yes, please come to the mic, identify yourself and go ahead.

MR. KAMPS: Hello. Good morning. Is this on?

CHAIRMAN BANERJEE: Is it on?

MR. KAMPS: I'm not sure.

CHAIRMAN BANERJEE: Yes.

MR. KAMPS: Very good. Thank you, Chairman and members. My name is Kevin Kamps, radioactive waste watchdog at Beyond Nuclear, and I'm also a member of Don't Waste Michigan representing the West Michigan chapter. And so, as Michael Keegan said just now, Palisades is of particular concern, but so is the Cook Nuclear Power Plant, Units 1 and 2, for our members and supporters in Southwest Michigan. And in addition, as a part of the Nuclear Free Great Lakes Task

Force we have concerns about Davis-Besse, Point Beach and we've been following various pressure temperature issues at pressurized water reactors including reactor pressure vessel embrittlement, other aging-related degradation issues. And so, in addition to the plants I've mentioned, some other plants we're very concerned about along these lines include Indian Point in New York, Diablo Canyon in California, Beaver Valley in Pennsylvania. I don't remember if I mentioned Davis-Besse in Ohio.

And I guess the public comment I would like to make is along the lines of the Associated Press exposé in June of 2011 about pencil whipping at NRC, the rollback of regulations to allow old age-degraded reactors to continue operating very much into the danger zone. We've certainly seen this with reactor pressure vessel embrittlement. Custom designed regulations for a plant like Palisades and some of the others I've mentioned, Point Beach, both of which are facing reactor pressure vessel embrittlement limits under the old regulations in 2017. And you have to wonder how much earlier that actually was. We have dates as far back at Palisades as 1995, actually. And so we're very concerned about this shaving of margins that I certainly heard some language today along those lines.

So, regarding Cook 1 and 2 we've been concerned about blockage of coolant flow to the reactor core ever since a whistleblower at Watts Bar, Curtis Overall, brought this issue to light and with the assistance of David Lochbaum at Union of Concerned Scientists forced the NRC to require an inspection at Cook Units 1 and 2. What was found when this inspection finally took place after a long period of resistance to doing the inspection was 13,000 pounds of debris blocking the coolant flow pathway leading to a three-year safety-related shutdown. Not only that, but also the discovery of a wall blocking coolant flow that was not on the blueprints.

So, that's certainly a question and concern I raise today is there are optimistic assumptions made, a lot of theorizing. What is the reality? There's talk of taking advantage of -- margins not taken advantage of in the past. But what are the plant-specific deficiencies? What are the plant-specific as-is ambitions that depart from the blueprints that will worsen the risks?

And just a couple things about process.

As Mr. Keegan mentioned, we only got the very limited documents that we did get pretty late in the day yesterday. It would certainly be helpful to get them more in advance and certainly more documentation.

A question that comes to my mind is the proprietary trade secrecy that's invoked. It's hard to understand because we have Westinghouse, we have AREVA; supposed competitors from different countries, actually, working together. We have the Pressurized Water Reactor Owners Group, which is two-thirds of the reactors in this country, working together on this. So I'm not sure who the trade secrets are being kept from. And this is very safety-related. I don't think this is directly about profit margins. This is really about safety. And so, we certainly protest the secrecy, call for more transparency and openness and accountability from all parties.

And along those lines would call upon both the NRC staff and the ACRS to certainly hold industry's feet to the fire. These are not brand new reactors. These are age-degraded reactors that have a multiplicity of problems and risks piling up. I mentioned reactor pressure vessel embrittlement.

So, the last point I wanted to make, too, because Mr. Keegan brought up the sumps and strainers at Palisades, I'm not very familiar -- I didn't attend that ACRS meeting in 2006, I don't believe. I haven't reviewed those documents, so I'm not familiar with the figures involved. Certainly Palisades would make the point that there were upgrades made, there were replacements made. Our question is are those replacements adequate? We're not sure because there's a long list of promises that were made at Palisades by the previous owner, by the current owner.

As Mr. Keegan indicated earlier the ACRS asked some tough questions at the time before the sale went down, before the license extension was approved by NRC. We have a long list of such promises that were not kept. The reactor pressure vessel embrittlement, for example. Dealing with that, addressing that issue took the form of a custom tailored regulation applying only at Palisades right now in the entire country, similar to today, taking advantage supposedly of margins that were not taken advantage of in the past. We have a problem with that.

The steam generator replacement that was promised never took place, and we have no indication that it will take place at Palisades. The reactor lid replacement did not take place. No indication that it will take place. So yet again another taking advantage of margins supposedly there on this issue. And so, we're quite concerned about the safety implications.

(Piano music playing)

CHAIRMAN BANERJEE: Thank you.

MR. KAMPS: Thank you.

CHAIRMAN BANERJEE: Very useful.

What happened there? We don't -- well, every time there's something new that happens.

(Laughter)

CHAIRMAN BANERJEE: So, let's get over this little blip and see if there are any other comments. We still have time to take comments. Can somebody who is listening in just make yourself known so I know the line is open and we can have other comments? Anybody?

MR. KEEGAN: Keegan.

CHAIRMAN BANERJEE: Great. Thank you.

MR. KEEGAN: Yes.

CHAIRMAN BANERJEE: Okay. So, before I

close this session and have a break, is there anybody else who wishes to make any comments?

MR. MUHICH: Hello. Yes, sir.

CHAIRMAN BANERJEE: Please, yes.

MR. MUHICH: Yes, my name is Mark Muhich, M-U-H-I-C-H. I'm in Michigan. I'm the chair of the Sierra Club, Beyond Nuclear, Nuclear Free Michigan and I'd like to comment briefly about the embrittlement issue at Palisades Nuclear Power Plant in Covert, Michigan.

As you probably know, the Atomic Safety and Licensing Board Panel decided that there was enough scientific evidence to warrant an evidentiary hearing about the embrittlement of their reactor pressure vessel, and I'd like to encourage the NRC to uphold that order and memorandum of June 18th, 2015. We feel it's extremely important that that reactor pressure vessel be physically tested. And that's what our scientific experts agree to and that's what the Atomic Safety Board also agreed to. So, I hope that the appeal by Entergy will not be upheld by the Nuclear Regulatory Commission.

And as far as scientific evidence, it should be very helpful to the NRC to determine just how factual their calculations are as that reactor pressure vessel has not been tested since 2003, and it's not been scheduled to be tested until 2019. So, the Sierra Club, Michigan, Nuclear Free Michigan is calling for that evidentiary hearing to go forward and that that reactor pressure vessel be immediately tested. So, thank you very much.

CHAIRMAN BANERJEE: Thank you. Any other comments?

(No audible response)

CHAIRMAN BANERJEE: Well, if there are no other comments, then I'm going to close this part of the meeting then. And what we'll do is we will take maybe -- we go into closed session now, actually. So, we'll close the meeting.

And, Weidong, let's make sure that all the lines and so on are closed. Thank you very much.

It usually takes a few minutes to close the meeting, so we'll take a five-minute break while we get the mechanics in order. So, just a brief break, five minutes.

(Whereupon, the above-entitled matter went off the record at 9:44 a.m.)

ACRS THERMAL HYDRAULIC SUB-COMMITTEE MEETING ON TOPICAL REPORT WCAP-17788 “COMPREHENSIVE ANALYSIS AND TEST PROGRAM FOR GSI-191 CLOSURE"

Jonathan Rowley (NRR/DPR)
PWR Owners Group Project Manager
October 20, 2015

Purpose of Meeting

- Present to Advisory Committee on Reactor Safeguards (ACRS) to gain insight and feedback on proposed methodologies
- Get feedback from ACRS early to increase review efficiency

Review Status

- WCAP-17788 submitted July 31, 2015
- Acceptance review pending
- Awaiting supplemental information
  - Justification of cold leg break fibrous debris limit defined in WCAP-17788 (Volume 3)
  - Scheduled for November 30, 2015 submittal
- Supplemental information audit
  - October 5, 2015

Review Schedule

- Major review milestones
  - Request for additional information by January 29, 2016
  - Draft safety evaluation by July 1, 2016
  - Final safety evaluation by September 2, 2016

Global Expertise • One Voice

Overview of WCAP-17788

In-Vessel Debris Limits for Closure of NRC Generic Letter 2004-02

Jeffrey Brown

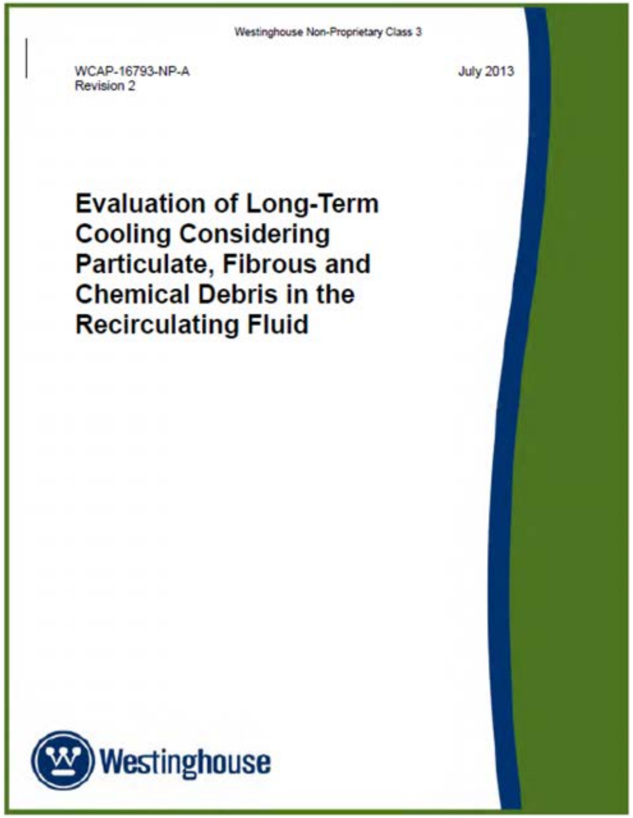
Pressurized Water Reactor Owners Group

October 20, 2015

History of Fiber Limits

WCAP-16793-NP-A, Revision 2

- Bounding Parametric Approach
- Single result applicable to all
- Determine generic fiber limit to ensure head loss is low and sufficient cooling flow
- No design of experiment
- Limited understanding of phenomena
- NRC staff approved WCAP in 2013



Westinghouse Non-Proprietary Class 3

WCAP-16793-NP-A
Revision 2

July 2013

Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid

Westinghouse

Bases for a Second PWROG Program

WCAP-16793-NP-A, Revision 2

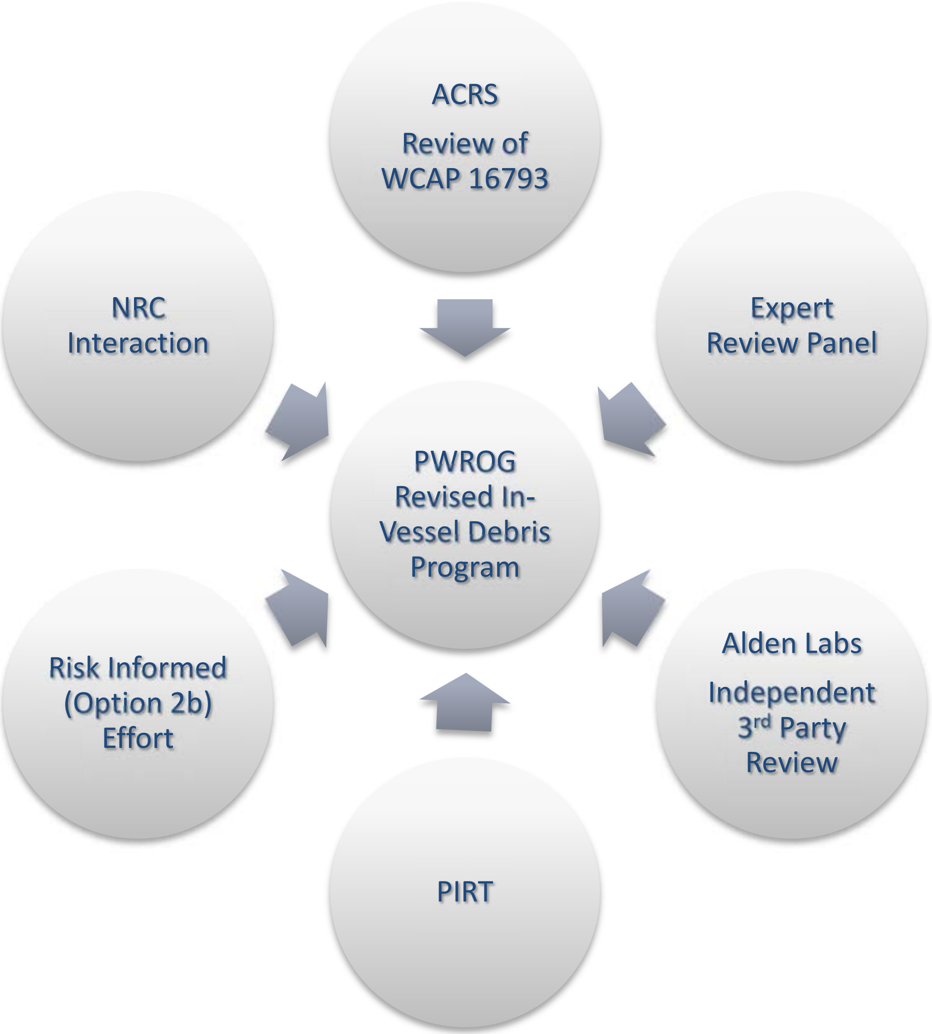
– Final generic result is acceptable for a limited number of plants (approximately1/3 of total number of plants)
– Minimal to no margin for many low fiber plants
– Significant analytic margins available to support increased limits

PWROG Executive Committee direction to establish technical team to redevelop PWROG In-vessel debris program

PWROG Developed a New Program for In-Vessel Debris (2012)

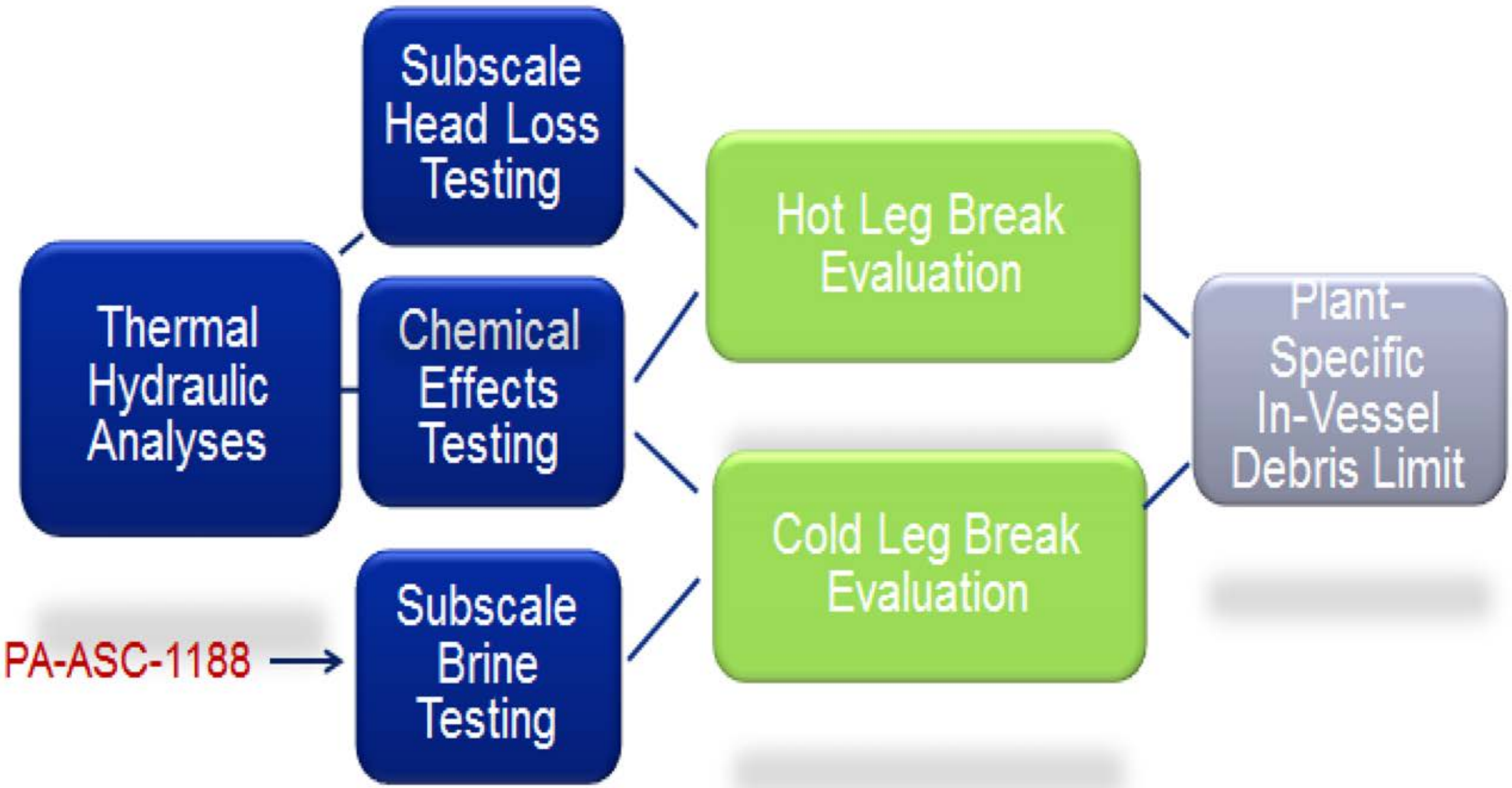
- Objective was to increase in-vessel fiber limits while demonstrating Long Term Core Cooling (LTCC)
- Establish phenomenological understanding of fiber beds
- Consider process timing
- Evaluate prototypical plant conditions (e.g., chemical effects)
- Include research preparation and literature review
- Use design of experiment

Program is based on a diverse set of inputs and oversight



PWROG Program Collaboration

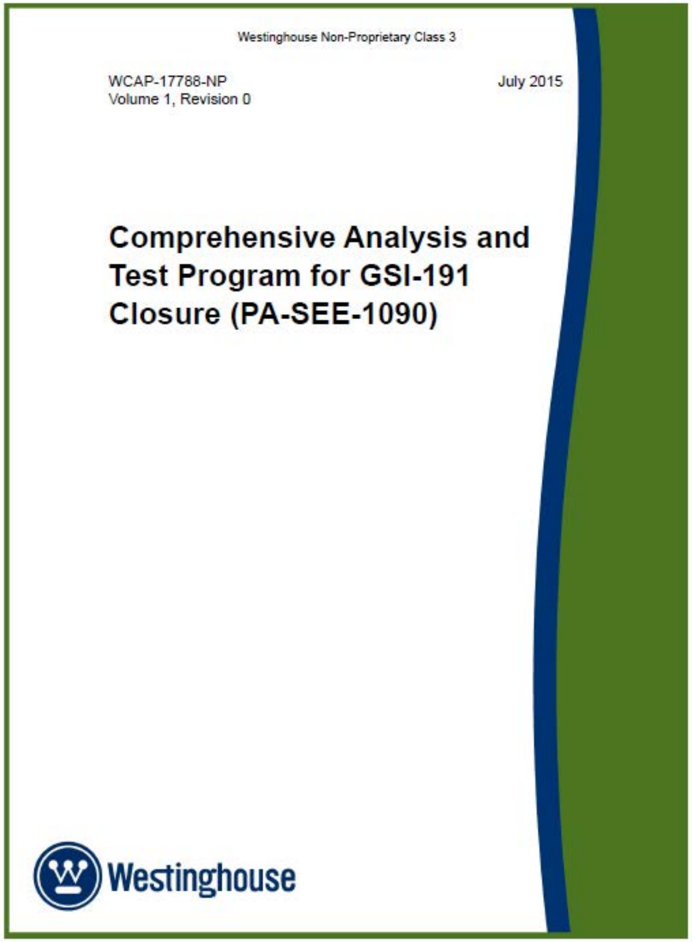
WCAP-17788 Program Organization



The New Program Improves on Previous Limits

WCAP-17788

- Methodology for plant specific application
- Considers HLB and CLB conditions
- Debris limits based on plant design
- Improved limits for all plants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WCAP-17788-NP
Volume 1, Revision 0

July 2015

Comprehensive Analysis and Test Program for GSI-191 Closure (PA-SEE-1090)

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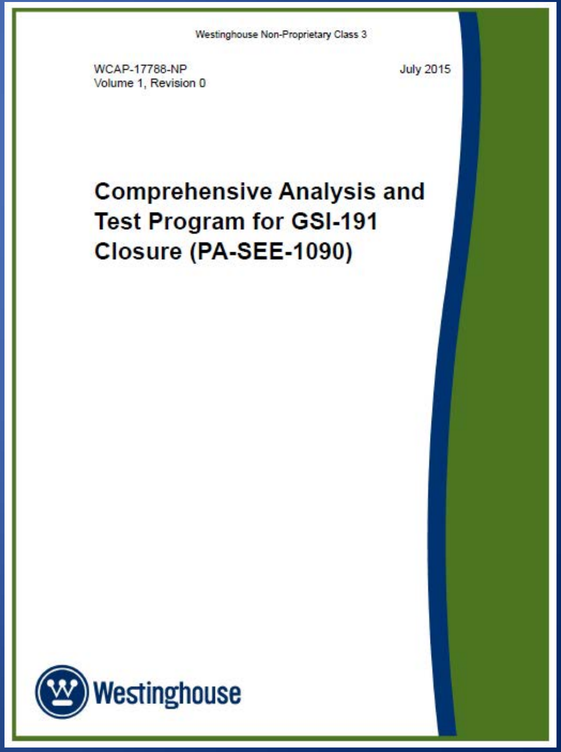
WCAP-17788 Volume 1 Introduction

Gordon Wissinger

AREVA Inc.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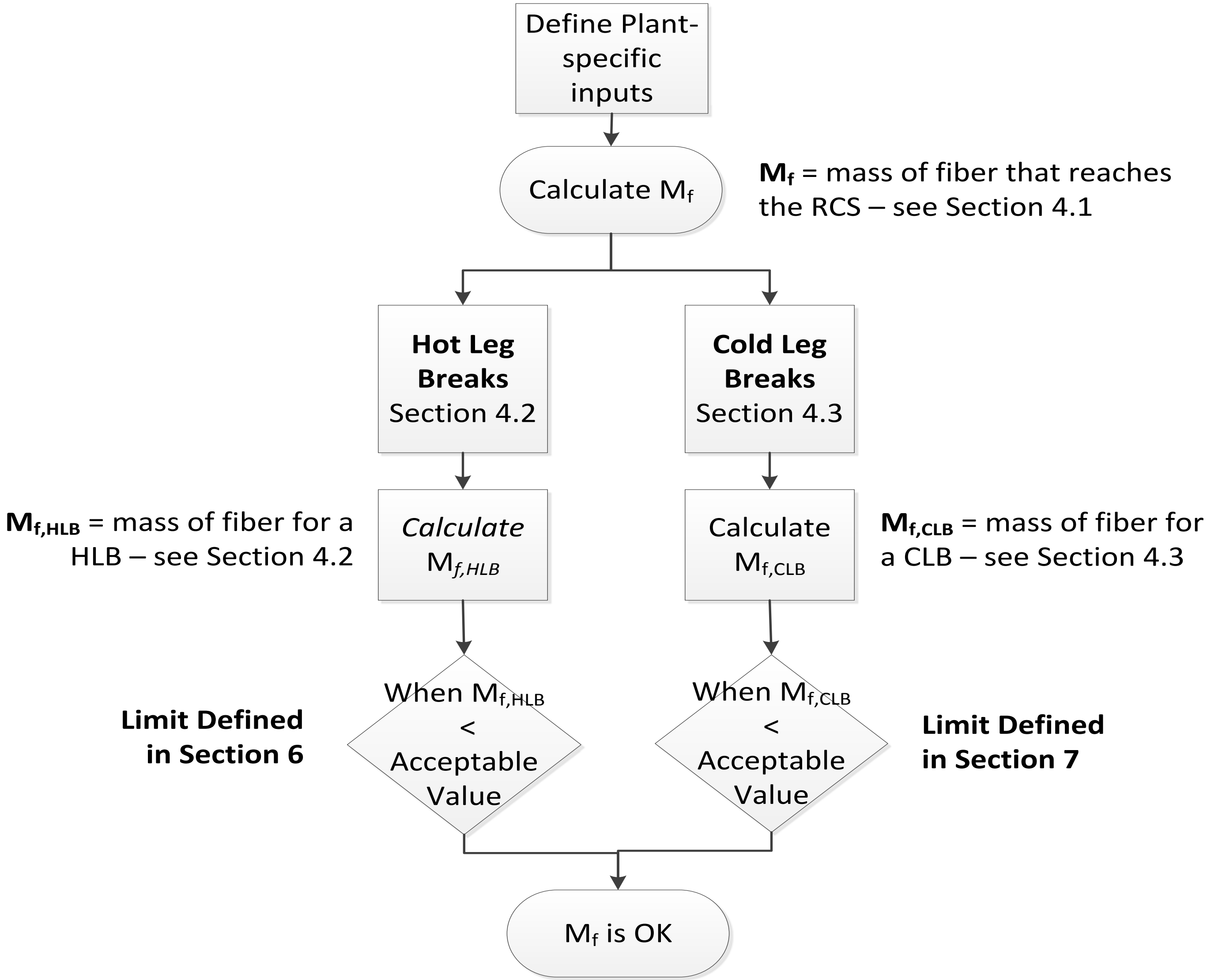
Volume 1 consolidates the results of 5 separate volumes of work:

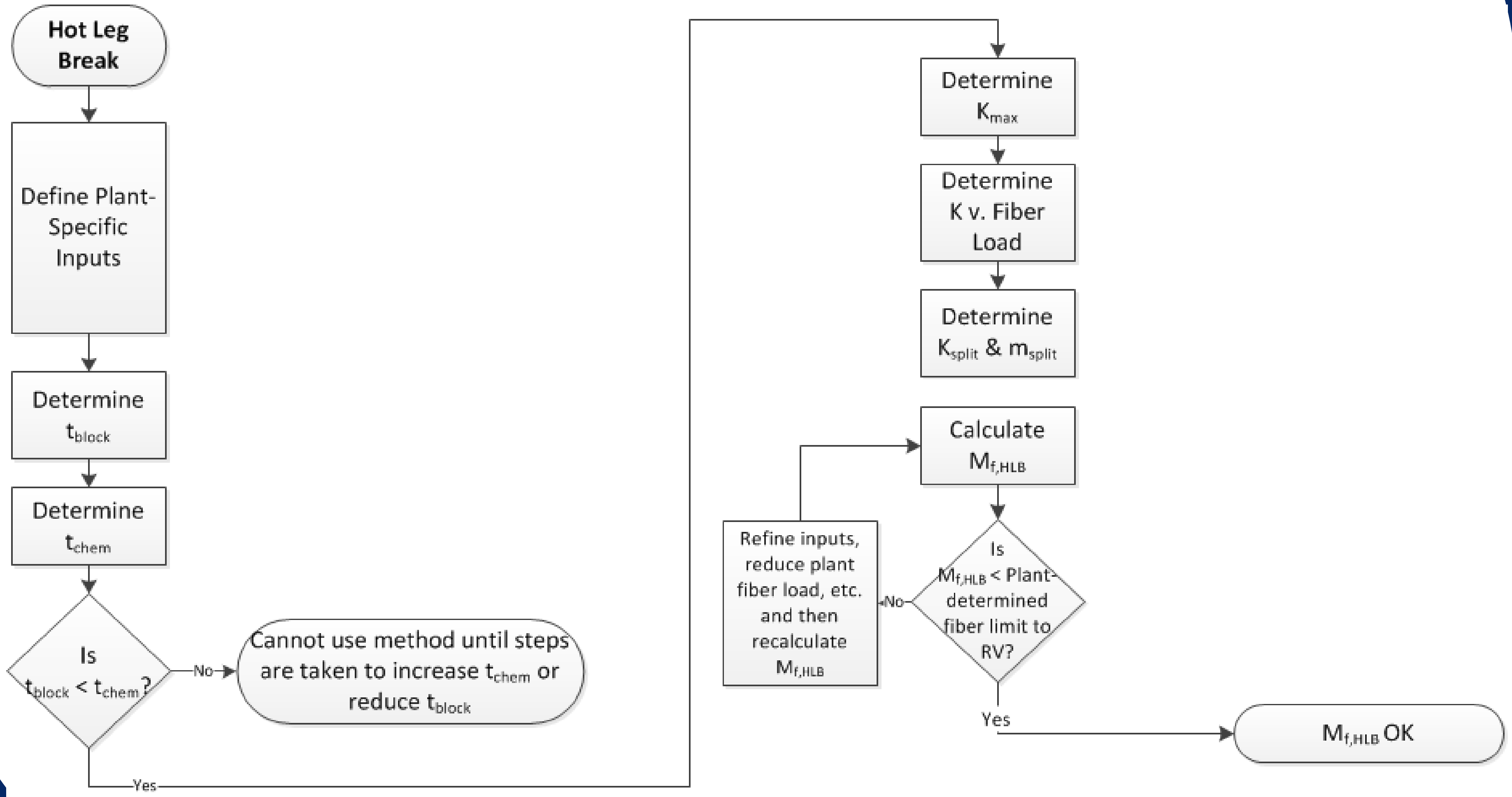
- **Volume 2** - PIRT
- **Volume 3** - CLB Evaluation Method
- **Volume 4** - TH Analyses
- **Volume 5** - Chemical Effects Testing
- **Volume 6** - Subscale Testing

This report presents the final results of a program coordinated and funded by the PWROG to develop a deterministic approach and methodology for assessing the time-dependent collection of fibrous debris in the RV for member utilities.

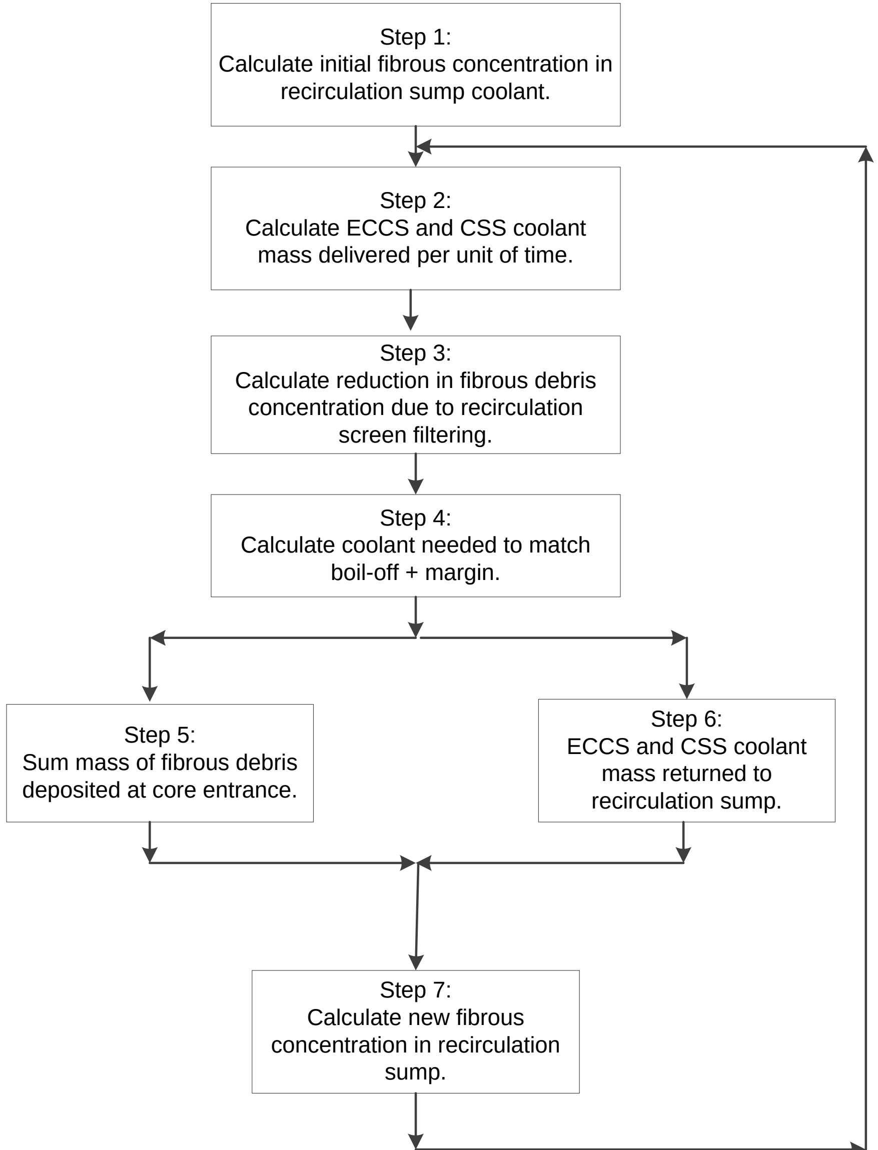
Volume 1 defines the method for determining a plant-specific in-vessel debris limit



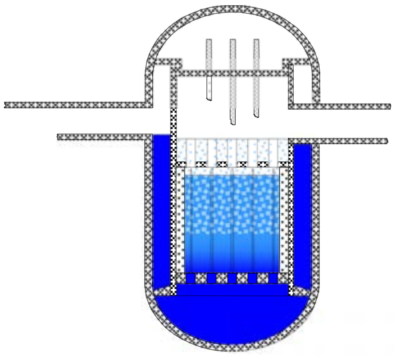
Volume 1, Section 4.2 defines the method for determining the HLB limit



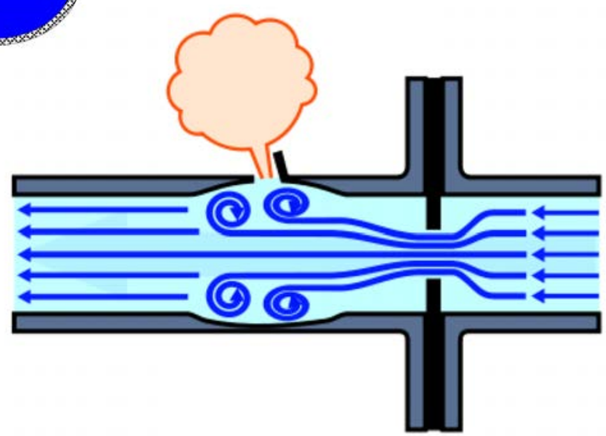
Volume 1, Section 4.3 defines the method for determining the CLB limit



The Volume 1 introduction defines the bases for determining a plant-specific in-vessel debris limit



Definition of In-Vessel Debris



Break Scenarios to Consider:

Size and Location

LTCC Acceptance Criteria

In-vessel debris is defined as the total debris mass retained in the reactor vessel

Total In-vessel Debris Mass

Debris Mass Collected at the Core Inlet (Debris Bed)

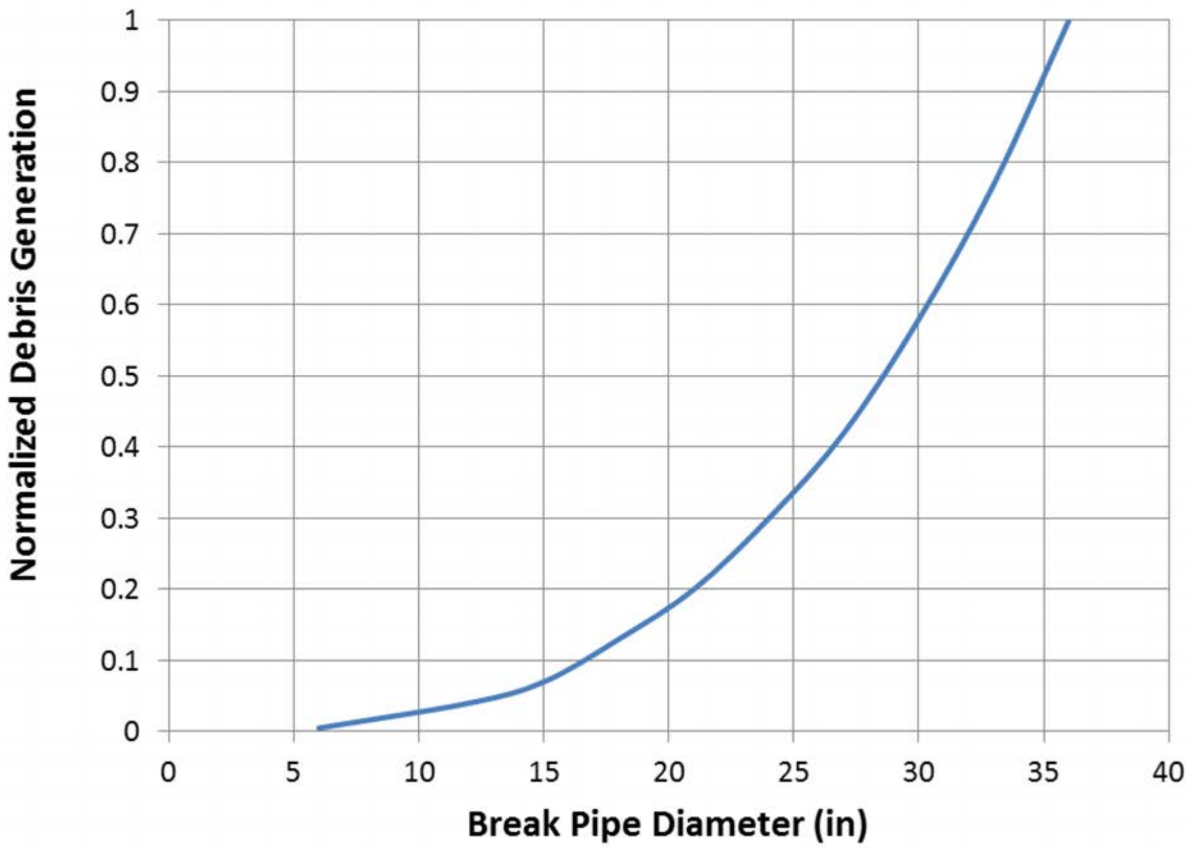
Debris Mass Collected in Core Region

Debris Mass that Exits through the Break

$$M_{In-Vessel} = \underbrace{M_{Core\ Inlet} + M_{Core} - M_{Break}}_{\text{Total Debris Mass Entering the RCS}}$$

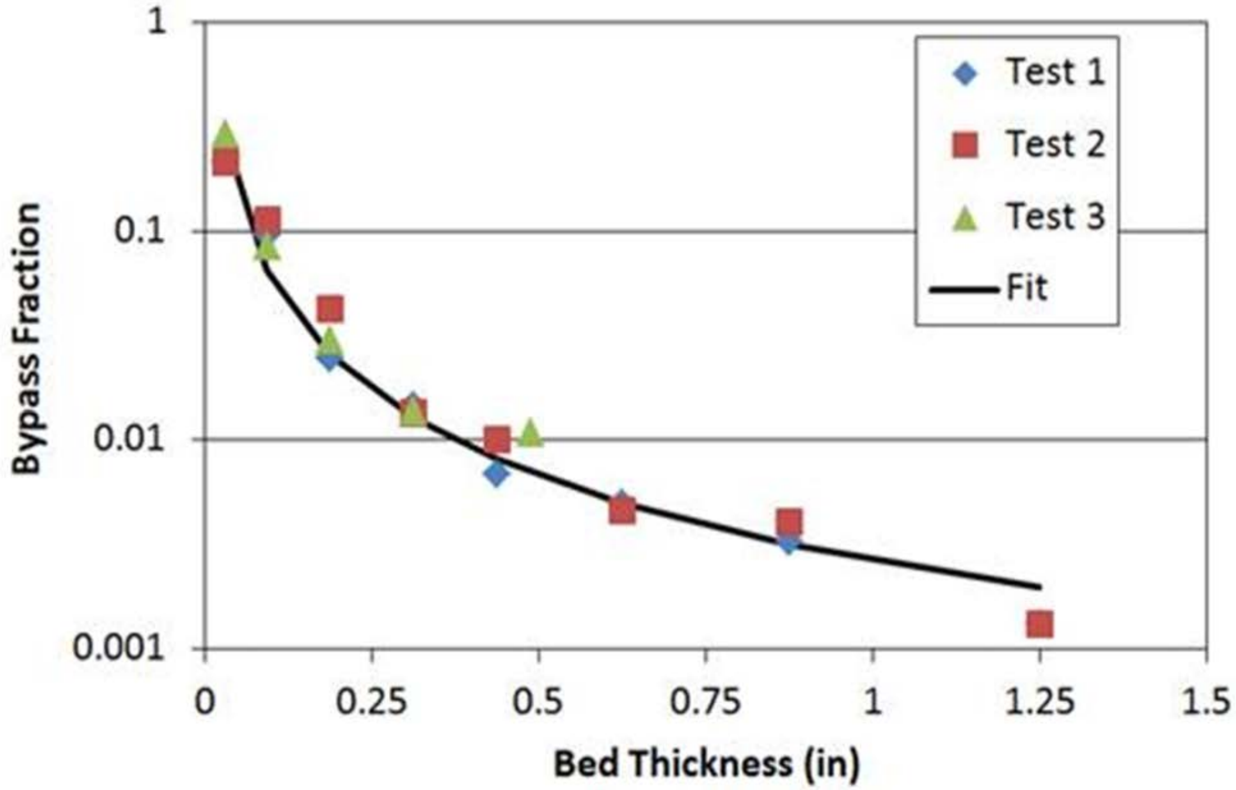
In-vessel debris accumulation only occurs at the core inlet or core region

Large breaks lead to higher generated debris loads in containment



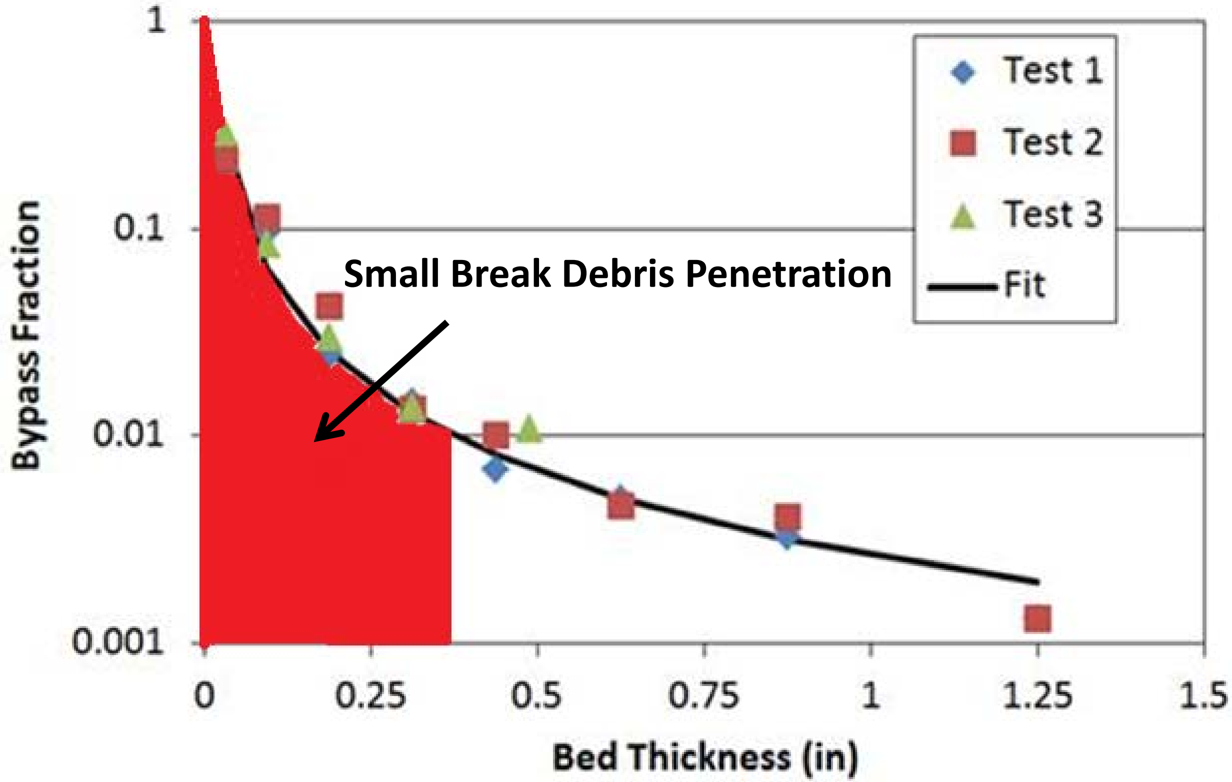
Debris generation increases by pipe radius to the third power

Large breaks lead to higher debris loads penetrating the sump strainer(s) and reaching the RCS



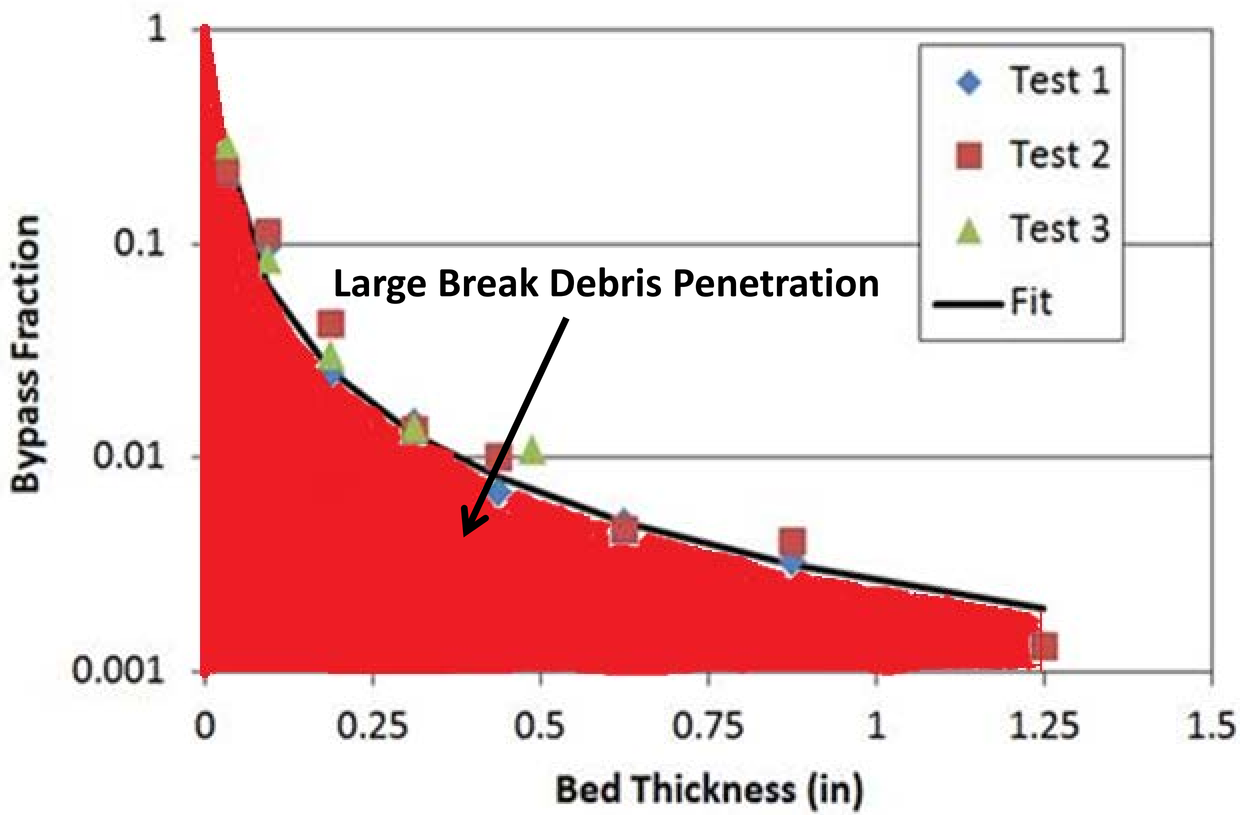
Large breaks generate the most debris, resulting in more debris transported to the RCS (integral of the curve)

Large breaks lead to higher debris loads penetrating the sump strainer(s) and reaching the RCS



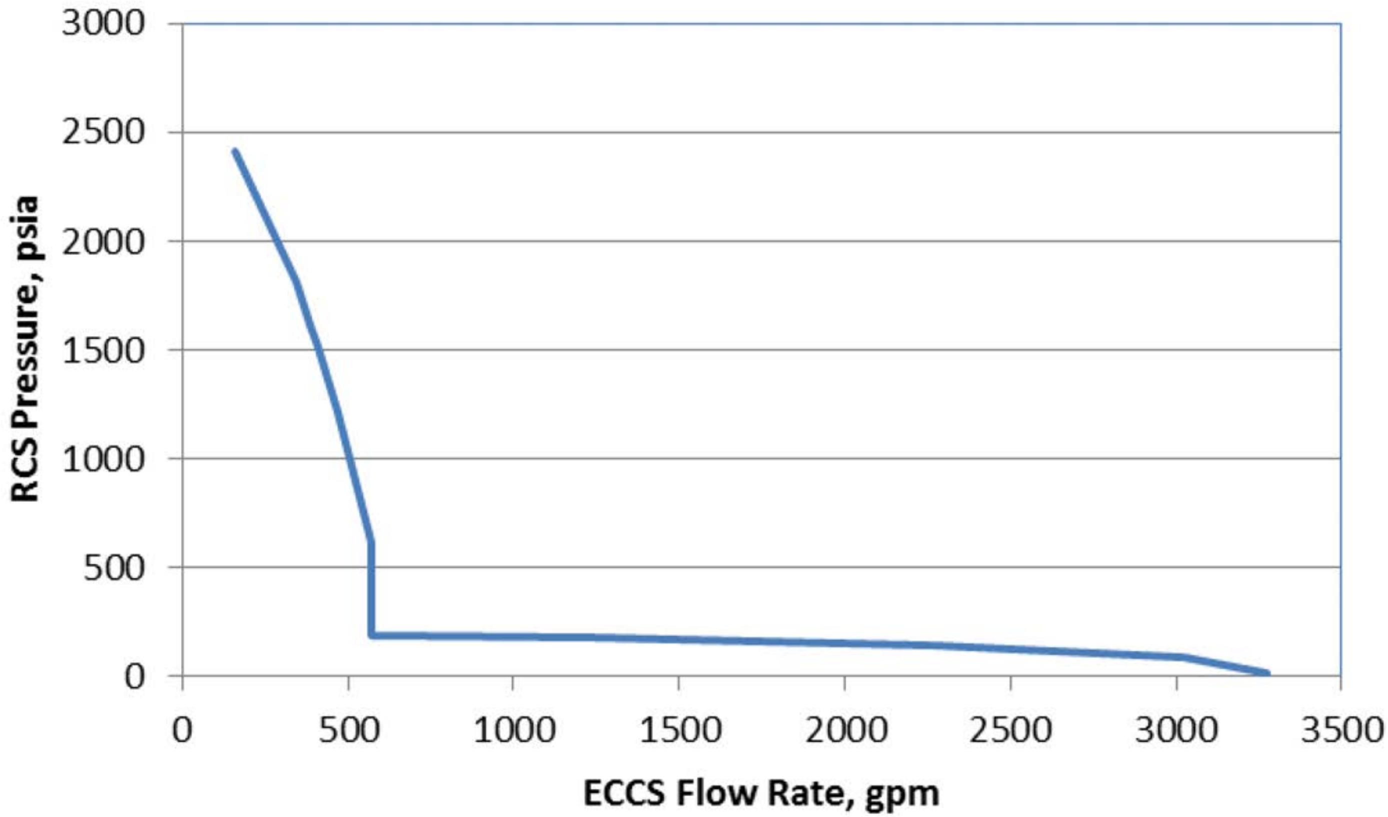
Debris bed on sump screen is thin because less debris is generated.

Large breaks lead to higher debris loads penetrating the sump strainer(s) and reaching the RCS



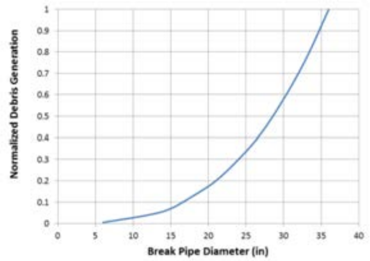
Debris bed on sump screen is thicker because more debris is generated.

Large breaks result in higher ECCS flows and faster debris arrival time to the reactor vessel

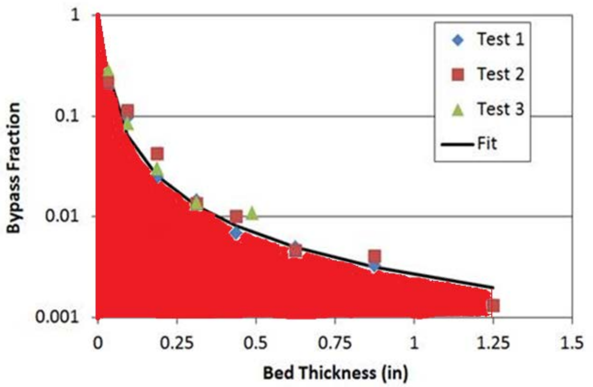


Debris arrival at higher decay heat is more limiting

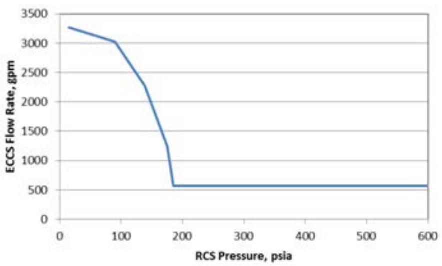
Full-area breaks bound smaller breaks with respect to GSI-191 and are the only breaks considered



Large breaks generate more debris



Large breaks will result in more debris through the sump strainer

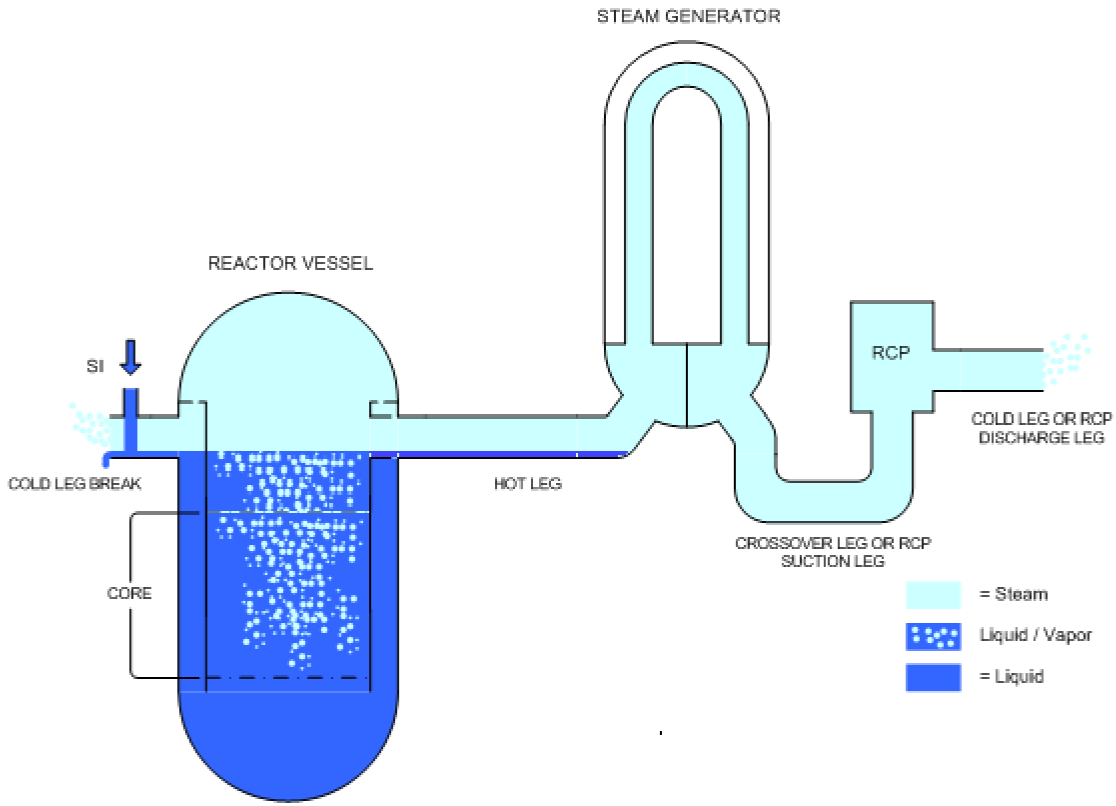


Large breaks will result in faster debris arrival

The break locations considered are divided into cold leg breaks (CLB) and hot leg breaks (HLB)

- Both break scenarios must be considered independently given the differences in the system response

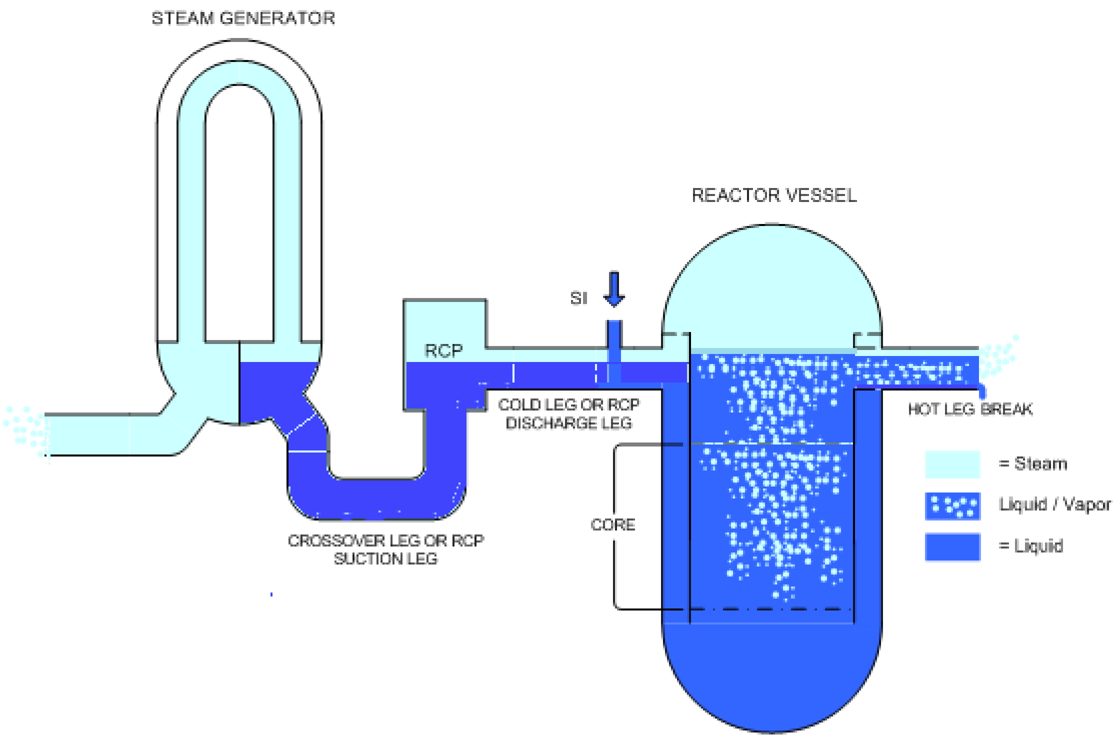
Large CLB Scenario



The break locations considered are divided into cold leg breaks (CLB) and hot leg breaks (HLB)

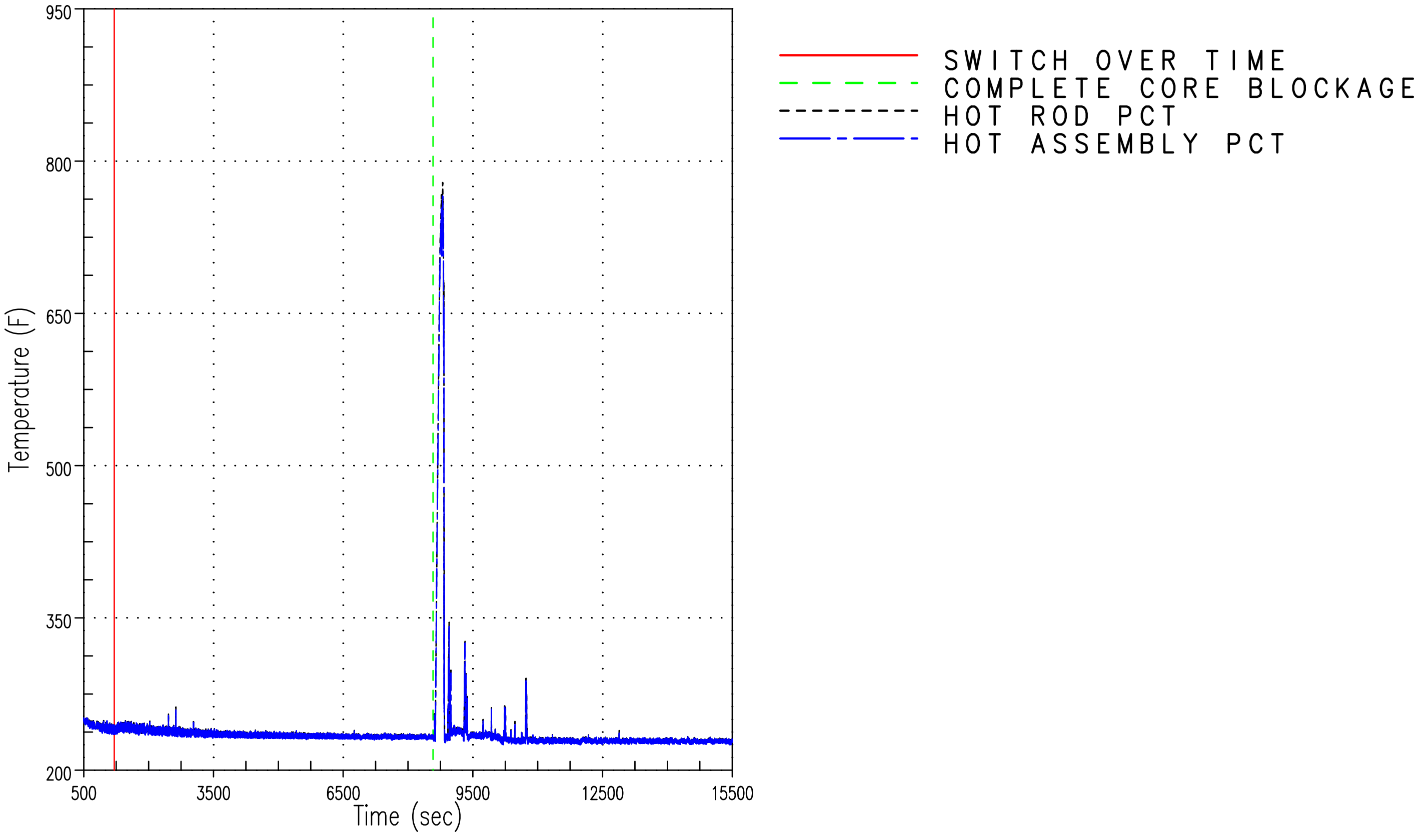
- Both break scenarios must be considered independently given the differences in the system response

Large HLB Scenario



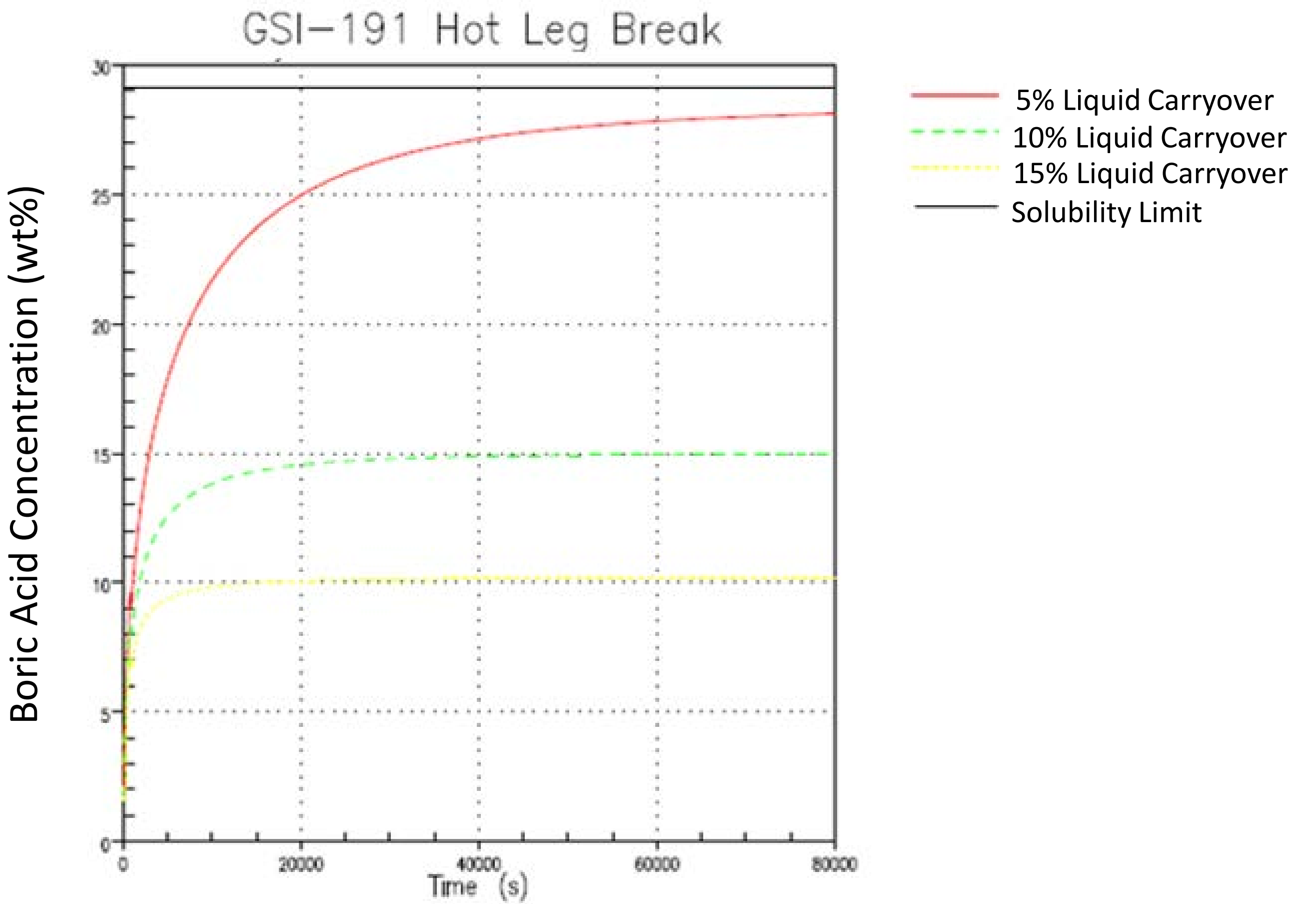
The acceptance criteria are established to adequately maintain LTCC after a postulated LOCA event

1. **Decay Heat Removal - DHR requires that sufficient coolant be supplied to the core such that the core temperature is maintained at an acceptably low level (post-quench heatup < 800°F)**



The acceptance criteria are established to adequately maintain LTCC after a postulated LOCA event

2. **Boric Acid Precipitation Control - BAPC requires that boron concentrations in the reactor vessel remain below the solubility limit**



The acceptance criteria are established to adequately maintain LTCC after a postulated LOCA event

1. **Decay Heat Removal - DHR requires that sufficient coolant be supplied to the core such that the core temperature is maintained at an acceptably low level (post-quench heatup < 800°F)**

2. **Boric Acid Precipitation Control - BAPC requires that boron concentrations in the reactor vessel remain below the solubility limit**

These acceptance criteria are sufficient to demonstrate compliance with 10 CFR 50.46 (b)(5) – Long-Term Core Cooling

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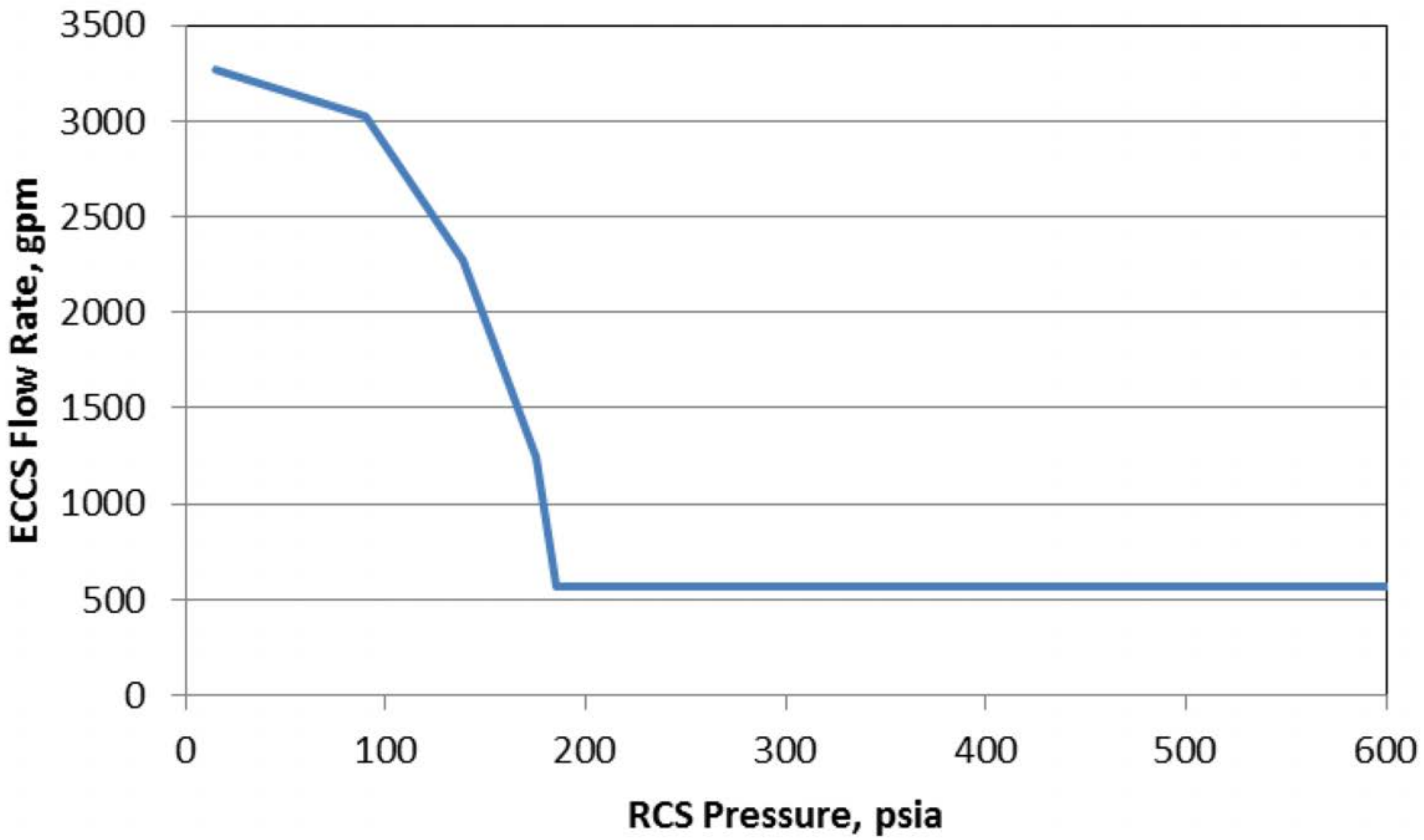
Backup Slides

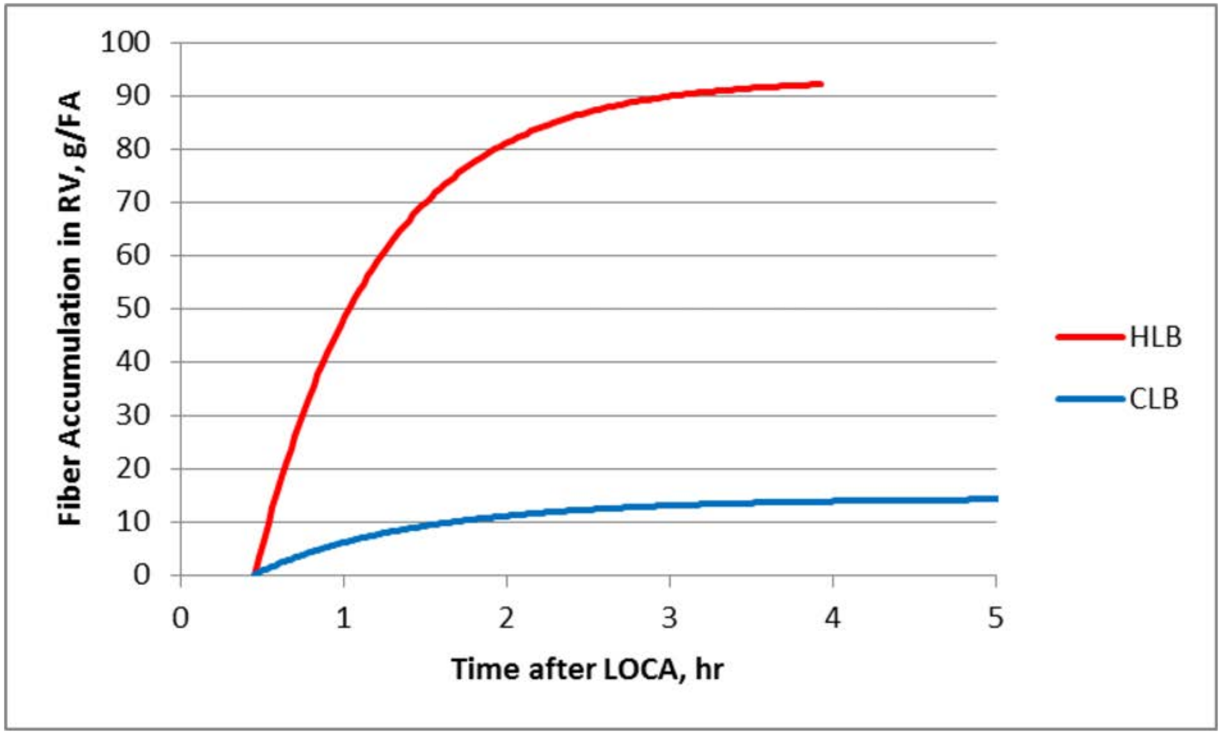
Large breaks result in higher ECCS flows and faster debris arrival time to the reactor vessel



Debris arrival at higher decay heat is more limiting

The break locations considered are divided into cold leg breaks (CLB) and hot leg breaks (HLB)

- Both break scenarios must be considered independently given the differences in the quantity of debris reaching the core



The break locations considered are divided into cold leg breaks (CLB) and hot leg breaks (HLB)

- Both break scenarios must be considered independently given the differences in the benefits of alternate flow paths (AFPs) for hot leg breaks