Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards Thermal Hydraulics Phenomena & Reliability and PRA Joint Subcommittee

Docket Number: N/A

Location: Rockville, Maryland

Date: September 03, 2014

Work Order No.: NRC-1046 Pages 1-586

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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

+ + + + +

THERMAL-HYDRAULIC PHENOMENA SUBCOMMITTEE

AND

RELIABILITY AND PRA SUBCOMMITTEE

+ + + + +

WEDNESDAY

SEPTEMBER 03, 2014

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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

DENNIS C. BLEY, Member

MICHAEL L. CORRADINI, Member

HAROLD B. RAY, Member

JOY REMPE, Member

STEPHEN P. SCHULTZ, Member

JOHN W. STETKAR, Member

ACRS CONSULTANT:

GRAHAM WALLIS

DESIGNATED FEDERAL OFFICIAL:

MARK BANKS

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

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

(8:31 a.m.)

CHAIRMAN BANERJEE: Good morning. This meeting will now come to order. This is a Joint Subcommittee meeting of the Advisory Committee on Reactor Safeguards, Subcommittees on Thermal-Hydraulics Phenomena and Reliability and PRA.

I am Sanjoy Banerjee, Chairman of the Thermal-Hydraulics Phenomena Subcommittee, and on my left is John Stetkar, Chairman of the PRA and Reliability Subcommittee.

ACRS Members in attendance are Steve Schultz, Harold Ray, Dennis Bley, John Stetkar, of course, and Joy Rempe. Mike Corradini was here but -- He's coming back in. Okay.

Our ACRS Consultant today, the former ACRS Chairman, is Dr. Graham Wallis and Mark Banks of the staff is the Designated Federal Official for this meeting.

So the purpose of today's meeting is for the NRC staff and representatives from the South Texas Project Electricity Generating Station to discuss the South Texas Project's risk-informed approach to resolving Generic Safety Issue 191. Generic Safety

Issue or GSI-191 is titled, "Assessment of Debris Accumulation on PWR Sump Performance."

The Joint 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 were announced as part of the notice of this meeting previously published in the Federal Register on August 19th, 2014.

The meeting will be open to public attendance with the exception of any portions that may be closed to protect information that is proprietary pursuant to 5 U.S.C. 522(b)(c)(4). We have received no written comments or requests for time to make oral statements.

A transcript of today's meeting is being kept and will be made available as stated in the Federal Register Notice. Therefore, we request that meeting participants use the microphones located throughout the meeting room when addressing the Subcommittee.

Participants should first identify themselves and speak with sufficient clarity and volume so they can be readily heard.

A telephone bridge line has been established for this meeting. To preclude interruption of this meeting, please mute your individual telephones and lines during presentations and Subcommittee discussion. I ask that you please silence all cell phones.

We will now proceed with the meeting and I'll call on Mike Markley, Acting Deputy Director of NRR's Division of Operating Reactor Licensing, to make introductory remarks. Thank you. Mike.

MR. MARKLEY: I'm Mike Markley. I'm the, again, Acting Deputy Director for Division of Operating Reactor Licensing and it's a great pleasure for me to come back here. I actually worked for the ACRS for six years so, Dr. Wallis, it's good to see you again.

Much credit is to be given to South Texas for the work they've done here. They've done a lot to advance the technology for the phenomenology of strainer blockage as well as the modeling of risk.

We spent a tremendous amount of time, I think we're up to about 4,800 hours of review time on this particular review and that doesn't include the pre-licensing time that we spent about 1,800 hours of review. So it's a lot of effort that both the licensee and the NRC staff have put into this.

Not to dilly-dally we turn it over and begin the presentation. Thank you.

MR. SINGAL: My name is Balwant Singal. I am the Senior Project Manager with the Division of Operating Reactor Licensing, Office of Nuclear Reactor Regulation.

Presently I'm the PM for South Texas Project also and the purpose of my presentation is just to give you a short overview of the status of the submittal under review by the NRC staff.

Just a little background slide where SECY-12-093 staff provided recommendations and there are three options and options are listed here but STP decided to pursue Option Number 2, and Option Number 2, it include the risk-informed approach so STP decided to be the pilot plant and pursue the risk-informed approach for resolving the GSI-191 issue.

CHAIRMAN BANERJEE: Just before you go I have a question.

MR. SINGAL: Sure.

CHAIRMAN BANERJEE: Within Option 2 there are sort of two sub-options, right?

MR. SINGAL: Option 2A and 2B.

CHAIRMAN BANERJEE: 2A and 2B. And they chose this risk-informed approach which is one of the sub-options.

MR. SINGAL: Yes.

CHAIRMAN BANERJEE: Do you have any views as to, and we may ask the Applicant as well, why they chose to do it this way?

MR. SINGAL: I think STP has an issue with a lot of fibrous insulation in the plant and they have, like they have to do quite a bit of modification and that's very expensive so they're trying to see if they can, by using the risk-informed approach, if they can eliminate the need for tons of modifications.

CHAIRMAN BANERJEE: Okay, so we'll repeat that question later. Thank you.

MR. SINGAL: We already kind of went through that. And then before we actually got back the submittal we had, 2011 we started with the pre-licensing actions and we had a total of --

DR. WALLIS: Let me ask you something, though, about this risk-informed approach. It seems to me that the risk-informed approach is a way of avoiding the large break because if you take the large break probability distribution it doesn't happen and that's the problem. So does the Commission know that that's really what's involved?

MR. SMITH: This is Steve Smith of the staff. I think that what we're trying to do, and it might be better for somebody from the PRA guys to answer this, but we are trying to ensure that South Texas's submittal meets the Commission guidelines for --

DR. WALLIS: Yes, I just wondered if the Commission's said any more than just risk-informed. I mean there's been talk of risk-informing LOCAs, the whole thing about the large break going away and that's another issue too. But does the Commission realize that what's sort of involved with this is making the large break much less significant than it used to be?

MR. SMITH: I think that they do know that because we've had several briefings with them and I think that they understand that it's based on break frequency and the probability of a large break.

DR. WALLIS: Good. Thank you.

MR. SINGAL: Between 2011 and 2012, we had about 18 pre-licensing meetings to discuss the various topics involved. If somebody's interested in the details of all those pre-licensing meetings, I do have separate sheets with me. I can provide the details.

The STP finally made the application on January 31st and that application included only a request for exemption.

The NRC staff had a lot of issues with the application. As a result, the application was revised in its entirety on June 19, 2013, which also included a license amendment request to change the licensing basis for the plant.

Then later on the licensee self-identified some errors in the application and they kind of revised it, resubmitted the entire application on November 13, 2013.

MEMBER CORRADINI: So just I haven't followed the history. I remember we had a briefing in 2012, so can you go back just so I understand? So all these were minor errors. They were self-identified. So the essence of what was proposed back in the end of '12 is still the same?

MR. SINGAL: It's still the same. It's just question of, like, when they submitted the first application that did not include a license amendment request.

STP believed that they can have the exemption and then make the change under 50.59. Staff did not agree with that. So then they resubmitted the application and included exemptions as well as license amendment request.

MEMBER CORRADINI: That's fine. Yes, I guess --

CHAIRMAN BANERJEE: So there is a little history here. Sorry. Could you explain what happened around June 19? They then submitted the license amendment request and the staff at that time did accept it or --

MR. SINGAL: That application was accepted.

CHAIRMAN BANERJEE: Accepted.

MR. SINGAL: But later on the licensee by themselves identified some errors in the application so they kind of basically, it was the same application, just making corrections to the errors they identified.

CHAIRMAN BANERJEE: And then they replaced it in its entirety if I understand you.

MR. SINGAL: Yes, but the review continued since June 19, 2013.

MR. MARKLEY: Right. One thing just, this is Mike Markley again, just to follow a little process timeline. There are a lot of discussions with the licensee and at various levels of the NRC, many of those at the policy level and the approach strategy that they were discussing.

When we got down to the nails and tacks of doing licensing, the approach of just doing an exemption wasn't sufficient for what they needed to get, the kind of relief and relaxation they were hoping for.

And we went through a lot of discussions. I mean from a licensing standpoint, our preference is almost always fix the plant over fixing the paper. Well, this is mostly focusing on the analysis of support, the paper.

So their approach is to justify through risk-informed methods, not really having to remove a lot of the fibrous insulation that they have and the large break LOCA that Dr. Wallis was talking about.

Now, they have done a lot of other things to fix the plant, things like strainers, advanced strainer designs and stuff like that, so it's a little bit of both.

But as far as the licensing, it's really, we're mostly processing the licensing actions to accommodate the kinds of requests that they're making. And there's more than one regulation involved so we have basically, what, three exemptions?

MR. SINGAL: Four.

MR. MARKLEY: Four exemptions, yes, four, so.

CHAIRMAN BANERJEE: But they have gone ahead, of course, and made lots of plant modifications, like replacing the strainers and --

MR. MARKLEY: Yes. Yes, correct.

CHAIRMAN BANERJEE: -- doing things to the containment spray and that sort of stuff, right?

MR. MARKLEY: Correct.

CHAIRMAN BANERJEE: Already?

MR. MARKLEY: Yes.

CHAIRMAN BANERJEE: And so you're looking at the plant as it stands today?

MR. MARKLEY: Correct.

CHAIRMAN BANERJEE: Okay.

MR. MARKLEY: Okay, go ahead.

MR. SINGAL: Just to summarize again, the application made on June 19 contained a license amendment request basically changing the licensing basis and it contained four exemptions from 10 CFR 50.46 and GDCs 35, 38 and 41 and, again, it was to use a risk-informed approach instead of using the deterministic approach.

CHAIRMAN BANERJEE: So --

MEMBER CORRADINI: So --

CHAIRMAN BANERJEE: Go ahead.

MEMBER CORRADINI: No, that's all right because maybe I don't appreciate what you mean by in this case exemption. So are we going to get back to that? I mean this is a process question but I'm still trying to understand.

So let's just take the first one. The exemption is really saying with the plant as it is today it can essentially satisfy that criterion of long-term cooling?

MR. SINGAL: No, the regulation right now required that they have to use the deterministic approach.

MEMBER CORRADINI: So a risk-informed approach requires an exemption? I'm sorry. I'm asking. Maybe I'm confused.

MR. SINGAL: The risk-informed approach is not acceptable the regulation right now.

MEMBER CORRADINI: Okay, so the very fact they chose Option 2, risk-informed, they need an exemption?

MR. SINGAL: Yes.

MEMBER CORRADINI: Okay, fine. All right.

CHAIRMAN BANERJEE: And how many plants are following this pilot lead?

MR. SMITH: I think there's 14 units.

CHAIRMAN BANERJEE: Besides STP?

MR. SMITH: Yes.

CHAIRMAN BANERJEE: Fourteen units.

(Simultaneous speaking)

MR. SMITH: Thirteen, okay, sorry. Thank you.

MEMBER CORRADINI: The number has changed.

CHAIRMAN BANERJEE: But just to remind us, Steve, how many plants have followed Option 1? Just give us a rough number. Doesn't have to be exact.

MR. SMITH: Probably 15 units or so.

CHAIRMAN BANERJEE: And they've, a number of them have finished the process and have gone through it and --

MR. SMITH: Yes, that's true. We've closed out ten units so far and we have some that just haven't sent in the documentation yet for us to review.

CHAIRMAN BANERJEE: And how many plants

are in Option 2A? That's the vast majority?

MR. SMITH: 2A's the majority, around 30.

CHAIRMAN BANERJEE: Okay. So these 15 or 13 plants are all high fiber plants?

MR. SMITH: Yes.

MEMBER CORRADINI: And 2A, they also have to seek an exemption?

MR. SMITH: 2A is a deterministic route so they would not have to use an exemption. All they're doing is they're taking a longer time to close out but they're doing more testing to justify it. They're not using a risk-informed approach.

MEMBER CORRADINI: So we're down, just to get to what I remember which is probably wrong, is they're down to changing the allowable debris per unit.

DR. WALLIS: Channel.

MEMBER CORRADINI: Channel. Thank you.

MR. SMITH: Yes, it's mostly all --

DR. WALLIS: Fill us in.

MR. SMITH: I think probably all those plants are just working on the in-vessel limit.

DR. WALLIS: Could you remind me when GSI-191 started?

MEMBER CORRADINI: In its current

numbering or way back when, when it was identified?

DR. WALLIS: When it started. When it was first, it first became an issue.

MR. SMITH: Well, you probably remember better than me.

DR. WALLIS: I'm just asking you to tell me.

CHAIRMAN BANERJEE: It's a rhetorical question.

MEMBER CORRADINI: This is an oral quiz. Get it right.

MR. SMITH: It was pre-2000, '98 or I don't know, '97?

DR. WALLIS: It's 16 years or something?

MR. SMITH: Yes.

DR. WALLIS: Seventeen years, and you knew then there was an issue with high fiber plants, right?

MR. SMITH: That's correct.

DR. WALLIS: They've been operating for 17 years without any resolution of that issue?

MR. SMITH: Well, but GSI, I don't think it's really fair to blame the plants for, from GS --

DR. WALLIS: I'm not blaming anyone. Just stating what I think is a fact.

MR. SMITH: Well, I mean, the GSI started and then research was done and then in 2004 we came out and directed plants to, you know, look at this issue, so.

DR. WALLIS: I remember. Yes, I remember.

CHAIRMAN BANERJEE: Steve, can I just interrupt and ask you a question because I'm trying to get it clear. So under 2A they're looking to the testing being done under the PWR Owners Group to get relief from the fiber loading or fuel assembly which has been approved by the staff at the moment?

MR. SMITH: That's correct. Right now our limit's 15 grams per fuel assembly so they want to increase that.

CHAIRMAN BANERJEE: But that's the only issue that they're waiting for to get some relief?

MR. SMITH: That's the majority. That's right. That's the majority of the plants.

CHAIRMAN BANERJEE: If the testing shows that?

MR. SMITH: Yes.

CHAIRMAN BANERJEE: Okay, that's clear then.

MEMBER CORRADINI: And, again, across this question and if the testing doesn't, they will bifurcate either to 2B or 1?

MR. SMITH: Yes, they would have to take action to get them into the current limit or do the risk-informed approach, yes.

MEMBER CORRADINI: Okay, fine. Thank you.

DR. WALLIS: I didn't quite get that. Is it now 15 grams? What is the approval?

CHAIRMAN BANERJEE: 15.

DR. WALLIS: How many?

MR. SMITH: Fifteen grams per fuel --

CHAIRMAN BANERJEE: Fifteen grams.

DR. WALLIS: It's now 15?

CHAIRMAN BANERJEE: It has been --

DR. WALLIS: How thick a layer does that make?

MR. SMITH: Well, it depends on what other debris gets into the --

DR. WALLIS: Just fiberglass by itself?

MR. SMITH: -- debris bed. But it can make a relatively thick layer.

DR. WALLIS: That doesn't mean anything to me. I mean my drain in my shower gets blocked with a microscopic amount of hair, so how much is this?

MR. SMITH: We can't really see how thick the layer is. We could probably go back and look and get you some pictures of that.

DR. WALLIS: Yes, I'd like to know. I'd like to get a picture of what it is. Fifteen gram doesn't sound like very much but I know it's very fluffy stuff so I'm just trying --

MR. SMITH: It's fluffy, right. So if it doesn't get compressed, it can be. But if it's not compressed, it doesn't create a lot of head loss, so.

DR. WALLIS: Yes so it's, you know, if it does, if, you know, if it begins to get up but --

CHAIRMAN BANERJEE: Okay, I think move on.

DR. WALLIS: -- maybe someone could tell me later on how thick that is.

MR. SMITH: Yes, right.

CHAIRMAN BANERJEE: I'd like to sort of limit the questions to questions for clarification so that, and informational. We don't want rhetorical questions B- or argumentative ones at the moment because otherwise we'll not finish by 5:00 and I'll miss my gym.

(Simultaneous speaking)

MEMBER SCHULTZ: Balwant, I didn't see it in your slides. What was the nature of the self-identified errors that were in play between June and November?

MR. SINGAL: They were like, they did analysis. The same time they made a submittal to summarize all the assumptions and inputs to the analysis. There were some differences between what they submitted to NRC and what they had in their analysis. They reconciled all the inputs and assumptions.

MEMBER SCHULTZ: So it was a matter of, if you will, submittal timing in some fashion, that they got the technical story --

MR. SINGAL: I think they have a lot of parties involved doing analysis and somehow some of the numbers didn't match.

MEMBER SCHULTZ: That explains it. That explains it enough. Thank you.

MR. SINGAL: The purpose of this slide is just to indicate it's a complex review and there are, like, number of NRR branches which are involved with the review. I kind of listed all the branches which are involved.

And on April 15, the NRC staff issued the

RAIs, the first set of RAIs. And just to give you an idea, there are about 150 RAIs and if you take the subparts there were, like, 250 RAIs. And some of the key issues which will be discussed today actually are listed here. STP responded to all the RAIs. There were about three different submittals. Those are also listed here with ML numbers.

NRC held a public meeting with STP on August 20. The purpose was to go over the responses we received and any gaps and STP is expected to kind of supplement their RAI responses as a result of that meeting.

NRC staff is also kind of planning to conduct a technical audit. Right now it seems like it will be the week of September 15 and the purpose of the technical audit is maybe to look at some of the documents which are not on docket.

MEMBER REMPE: Could you expand a bit more? I mean is this the, this surely isn't the first time you've gone down there for some sort of audit or is this the first time?

MR. SINGAL: Technical audit, this is the first technical audit, yes.

MEMBER REMPE: And are you going to focus on, I mean there's been an extensive amount of analysis. Do you have any particular area where you plan to focus?

And then also it sounds like they were doing self-identification of errors. What kind of QA process is, I mean you'll be doing your checks and independent audits but don't they have some sort of QA process in place that would have precluded some of these self-identification of errors?

MR. SMITH: Yes, I think we probably ought to let STP talk about their QA process so, you know, if you could ask them.

But as far as the areas that we're going to be covering in this audit, it's going to be the areas that we have the majority of the RAIs on and I don't know if you guys have been able to look at those or not.

MEMBER REMPE: There are a lot of --

MR. SMITH: But there's going to be, it'll be in the area of head loss, chemical effects, coatings. Those are the major areas that I think we're going to be looking at during the --

CHAIRMAN BANERJEE: What about, you know, one of the issues that arises here is what they call penetration which you could call whatever, bypass.

MR. SMITH: Yes, bypass for instance.

CHAIRMAN BANERJEE: And it's sort of crucial that one gets that right because if you increase the area of the strainers and you reduce the amount of -- Because if you're only considering smaller breaks or predominantly, then this penetration tends to go up with, like, loadings on the strainers. Is that a critical issue you're going to look at when it --

MR. SMITH: That is a critical issue. They have done testing to determine how much fiber would bypass the strainer. We have some questions about how the results of that testing was implemented in their model. So there are some, we've done some playing with their model and there are some funny things going on with that. So we do have questions about that.

CHAIRMAN BANERJEE: Okay, thanks. Who's going for the audit?

MR. SMITH: I think we have several people going.

CHAIRMAN BANERJEE: You will be going yourself?

MR. SMITH: I'll be going. We have some people from --

CHAIRMAN BANERJEE: Paul going?

MR. SMITH: We also have questions. I

should have listed. We also do have questions in the PRA area, which I didn't mention that one. I don't think about the PRA part that much but luckily we have some smart guys who do that. Paul is going and Matt Yoder will be going and a few other people.

DR. WALLIS: Can I ask is it worthwhile for the ACRS to get involved in these technical issues yet or should we wait until you've done your audit and reached some sort of preliminary conclusion?

MR. SMITH: Well, I think that, you know, we always think that you guys provide good insight so, you know, the sooner you get involved, it would actually help us if you guys were involved.

DR. WALLIS: So you want to give us data to look at?

MR. SMITH: I think we've given you a lot of information but if there's more information we could give you we can do that. I mean, as long as --

DR. WALLIS: I haven't seen anything personally but maybe these other guys have.

CHAIRMAN BANERJEE: We'll discuss that offline, whatever we need.

MR. MARKLEY: We really did want to come here early rather than be another six to eight months in the review process. Since we're still in the middle of reconciling RAIs and so forth, it didn't make sense to come here. We would certainly come back when we have our safety evaluations but it wouldn't make sense to wait that long. If you have issues that you feel are worthy for us to consider, we'd be delighted to have them.

CHAIRMAN BANERJEE: Okay, great.

MR. SINGAL: Just to answer your question, again, we are planning to have at least two more additional ACRS Subcommittee meetings followed with a full Committee meeting.

Right now the way that we are going it's expected that NRC staff will make the final decision around December 31, 2015.

This is just a timeline of the whole thing I just went through. Any questions?

CHAIRMAN BANERJEE: If there are no questions, thank you and let's move on to the, I guess it'll be Tara, right?

MS. INVERSO: Yes.

(Off microphone discussion)

CHAIRMAN BANERJEE: It's good to see that there are people involved on the staff side who have been with this right from the beginning and have the history and understanding of there are so many issues and so complex and that also makes us feel a lot more secure.

MR. SMITH: One of the key reviewers I should mention is CJ Fong. He's from the risk assessment area so he'll be going also on the audit with us.

CHAIRMAN BANERJEE: Okay.

MS. INVERSO: Okay, my name is Tara Inverso. I'm the Chief of the Rulemaking Branch in NRR and I'll be talking very briefly about the tie between the South Texas Project pilot and the 10 CFR 50.46c performance-based ECCS cladding proposed rule.

To give an overview of the proposed rule, there are several objectives. The original objectives as we original proposed it to the Commission was to revise the ECCS acceptance criteria to reflect recent research findings and those were mostly related to the role of hydrogen and embrittlement, to replace prescriptive analytical requirements with performance-based requirements, to expand the applicability to all fuel design and cladding materials.

Right now the 50.46 regulation is

applicable to Zircaloy and ZIRLO, which are spelled out in the rule. This proposed rule would expand that to all fuel designs and cladding materials.

And it also addresses concerns raised in two petitions for rulemaking. The first was PRM-50-71 which was submitted by the Nuclear Energy Institute in the early 2000s and requested that expansion of applicability to preclude the need for so many exemption requests.

And then more recently in the 2008 time frame Mr. Mark Leyse submitted PRM-50-84 which requested that the regulation account for the thermal effects of crud and oxide layers.

So the staff proposed the rule to the Commission back in the March of 2012 time frame and in January of 2013 the Commission issued its Staff Requirements Memorandum and part of that was to allow the use of a risk-informed approach such as the one we're hearing about today to evaluate the effects of debris on long-term cooling and that became the fifth objective.

So as I mentioned, the SRM was issued on January 7, 2013. The actual text of the SRM is provided in that sub-bullet, that the rule should contain a provision allowing NRC licensees on a case-by-case basis to use risk-informed alternatives without an exemption request.

DR. WALLIS: Could I -- I'm sorry. I've been away from this for a while. You talk here about debris. Does this apply also to short-term cooling?

MS. INVERSO: That has been a discussion at a lot of the public meetings that we've had. Right now the high-level rule language applies only during the long term and only for the effects of debris.

DR. WALLIS: But why is there a difference? It seems to me you kept a cooler core for the short term and long term so there has to be some sort of equivalence.

MS. INVERSO: Right, and that's something that we've talked about at the public meeting, is when does the transition from the short term to the long term happen? And I expect that we'll see some of the public comments touch on that same thing so we'll have to evaluate that.

DR. WALLIS: So it's still going on?

MS. INVERSO: Yes.

DR. WALLIS: Okay.

MS. INVERSO: When it was written it was

just for the long term. So the staff read the language. We had some alignment meetings with the Commissioner's assistance and we interpreted that language to mean that licensees such as the South Texas Project would come in with their proposals and not need any of the exemption requests that we talked about during the previous presentation.

MEMBER CORRADINI: So just to be clear, from a process standpoint it's just a different way to the same end. What South Texas would choose to do technically, whether it's under exemption or under this rule, wouldn't change?

MS. INVERSO: Yes. It was just for efficiencies.

MEMBER CORRADINI: All right. I just wanted to make sure I understood.

DR. WALLIS: This is very interesting because risk informed depends on your ability to evaluate risk, and when new events occur or new knowledge comes in, your ability to evaluate risk changes so how do you --

MEMBER STETKAR: Your ability to evaluate risk remains the same. Your evidence changes.

DR. WALLIS: But the evidence is different so your conclusion might be different. Thank you very much, John. I'm just curious about how risk informed deals with new information which might make the risk now appear to be bigger.

MR. SMITH: There is a requirement for any plant that uses a risk-informed evaluation to update their model, you know, I think it's every few years, maybe every four years, is it, every four years to take into account new things that are learned, changes to the plant, things like that. And if they do anything to the plant in the interim that would have an effect, they also have to evaluate that.

MEMBER CORRADINI: So in this case, though, the staff has yet to determine the performance basis. There's a methodology we're going to learn about or re-hear about since we heard about it in May of '12.

But in terms of what the cutoff is given the analysis, that's yet to be determined. They might be for something proposed from the applicant but at this point what's on the good side or what is on the acceptable versus unacceptable side is yet to be determined by staff, is that correct?

MR. SMITH: We would use Reg Guide 1.174 as sort of the overarching risk-informed Reg Guide that we would use to establish that type of criteria. There's different regions --

MEMBER CORRADINI: So when we get to that point, you'll remind us on how you apply it here?

MR. SMITH: Yes.

MEMBER CORRADINI: Thank you.

MR. SMITH: Or I'll get CJ to.

MEMBER CORRADINI: Thank you.

MS. INVERSO: So the way the proposed rule is structured now the rule language is very high level. The details would be contained in a Regulatory Guide and the proposed rule, when it was published, had a question on whether that was the preferred structure or whether the detail should be within the rule language itself.

The cumulative effects of regulation require that draft guidance be issued with proposed rules and final guidance with final rules.

In this particular case, we identified that portions of 50.46c were required to maintain adequate protection so we had a desire to publish the proposed rule and then the final rule as expediently as possible, yet we also knew that the draft guide for this one risk-informed piece would be tied to the staff's review of the South Texas Project submittal.

So we requested permission in COMSECY-13-0006 to decouple just that one draft guide from the proposed rule. So the proposed rule was issued with three draft Regulatory Guides related to the original objectives.

For this added objective of the risk-informed alternative, we're following the South Texas Project review and are going to publish a draft guide for comment, probably in spring of 2015. That would allow us to collect the comments and to issue a final guide concurrent with the final rules so all the guidance would be available upon final implementation.

CHAIRMAN BANERJEE: When would that final rule be then?

MS. INVERSO: Right now it's due February of 2016 to the Commission so after --

CHAIRMAN BANERJEE: So you could get the guide out in final form by then?

MS. INVERSO: We think so.

CHAIRMAN BANERJEE: Within less than a year?

MS. INVERSO: So it would have about a 75-day public comment period and then we could collect the comments in the fall and tidy that up and get it there. And then there would also be time for the Commission to evaluate the final rule and we could still --

CHAIRMAN BANERJEE: So the staff would, concurrent with this review, prepare the guide?

MS. INVERSO: Yes.

CHAIRMAN BANERJEE: That's a pretty heavy workload I would say.

MS. INVERSO: It is.

MEMBER CORRADINI: And the rule is on track?

MS. INVERSO: It is, yes.

CHAIRMAN BANERJEE: All right. You guys seem gluttons for punishment. All right.

MS. INVERSO: And more details on the rulemaking timeline. There was an Advance Notice of Proposed Rulemaking published in August of 2009. That followed the technical basis that was published in the 2008 time frame.

We presented the proposed rule in the three draft Regulatory Guides related to the research findings in January of 2012 and provided the proposed rule to the Commission in March of 2012 and then the SRM was issued in January of 2013.

This next bullet has a little typo in it. We had a series of public meetings during this year, from April to July. I think it was about six or seven days of public meetings total.

So that was good for the staff to be able to describe what it intended the rule language to mean and then for the industry and members of the public to present what their initial thoughts were and we think that will help us understand the public comments that are trickling in.

We also had the opportunity to be briefed by Mr. Leyse about his PRMs and how they're being addressed in the proposed rule.

MEMBER CORRADINI: And besides that one mention, are there other things that stand out from the public meeting?

MS. INVERSO: We mentioned a little bit the transition from the short term to the long term. There was some discussion of whether or not we would need additional guidance in the area of long-term cooling, even the deterministic side.

So separate from this risk-informed piece there was some change in the language to how the long term would be considered. There was some talk about moving Appendix K into a Regulatory Guide.

MEMBER CORRADINI: Okay, fine.

MS. INVERSO: Okay. Yes, there was --

MEMBER CORRADINI: So it sounds like a lot.

MS. INVERSO: There was a lot of discussion, yes. Yes. And the public comment period was 150 days. It was almost doubled in length. And as of now, we have about 28 public comments and the comment period closed on August 21st. So the staff is beginning to evaluate those comments.

And next steps, we're scheduled to meet with the ACRS Subcommittee in December of 2014, so in a few months from now, and the purpose of that meeting is for information because this will have a lot of documentation with it.

So ACRS and the NRC staff thought that it would be best to periodically meet with ACRS. During that time, we can provide more detail on the comments that we've received and the staff's initial reactions.

We can also provide an update on the fuel fragmentation, relocation, dispersal phenomena which, as of now, is not within the rule but the SRM directed the staff to complete all research and include it in the rule or write an information paper on why it's not feasible to do so.

MEMBER CORRADINI: Based on LOCA?

MS. INVERSO: Yes. And the final rule is due to the Commission --

CHAIRMAN BANERJEE: Which Subcommittee was that? Was that Harold's?

MEMBER STETKAR: We'll look it up.

MS. INVERSO: It's not on the agenda right now.

MEMBER STETKAR: We need to get to the technical stuff here. This is B- it's probably reg policy.

(Simultaneous speaking)

MEMBER STETKAR: Well, I have it here.

CHAIRMAN BANERJEE: Okay, keep going.

MS. INVERSO: And as we mentioned, the final rule is due to the Commission in February of 2016 and that's with all of the guidance. And we mentioned that, in parallel, we're developing the draft guide for the risk-informed treatment of debris.

And next Steve will walk us through Slide 6.

MR. SMITH: Yes, this is the only reason I was really up here, to talk about this slide. Probably about a month ago we had a NEI-sponsored group come in and present to us an alternative risk-informed methodology. It's scalable and what they plan on doing is use deterministic methods to the extent possible.

And then this third bullet kind of gets to your point. Most of the analysis or the risk would be just based on pipe break frequency, you know, so the large break LOCA, how frequently that's going to occur and that would determine how much risk they would have to add to their, you know, would be added to the plant.

So they're going to use staff-approved methods for most of the other areas that we usually talk about when we talk about GSI-191 and they would, if they had to do something -- Say they didn't meet their risk metrics just based on pipe break frequency. They might come back and take some of the conservatism out of some of these other areas, but we'd have to review those on a case-by-case basis.

And the debris limit that gets to the strainer would be based on testing or an agreed-upon minimum amount of debris that would get to the strainer to ensure acceptable head loss.

MEMBER CORRADINI: This was just a month

ago?

MR. SMITH: We had a meeting a month ago. I think it's been in the making for a while. We had heard rumors that industry was working on doing alternate approach for quite a while.

DR. WALLIS: So the technical stuff is going to be in the next presentation by South Texas?

MR. SMITH: Right, South Texas.

DR. WALLIS: You're not going to present any technical stuff to us, is that right?

MR. SMITH: I'm not going to present you any technical stuff.

DR. WALLIS: Thank you.

CHAIRMAN BANERJEE: But this staff-approved methods, so to speak, are not what South Texas is presenting here?

MR. SMITH: In some areas they use the staff-approved methodology and they incorporate that into their model which is called CASA Grande. So some of the things that we have differences with them on is, like, the way they calculate head loss because they're using a correlation for that so, you know --

CHAIRMAN BANERJEE: Yes. So that, for example, is just taking that? I mean at the moment the staff requires a different approach from 6224, right?

MR. SMITH: Right.

CHAIRMAN BANERJEE: But they are using 6224?

MR. SMITH: Right. They add some conservatisms, things like that.

CHAIRMAN BANERJEE: Whatever, yes.

MR. SMITH: So we're discussing all this, yes.

CHAIRMAN BANERJEE: Yes, but the point here is that the presentation a month ago basically said other than the pipe frequency and size everything else is as we do it today?

MR. SMITH: That would be the best case for us, the easiest, most simple way for us to review.

CHAIRMAN BANERJEE: Yes, so we understand what we are doing, yes.

MR. SMITH: Right. They may take some conservatism out of some of these areas in order to meet, if they have to, but they would attempt to use, like, the NEI 04-07 approved methodology for --

CHAIRMAN BANERJEE: So, for example, they were looking at the zone of influence. They were doing some experiments.

MR. SMITH: Right.

CHAIRMAN BANERJEE: What you're saying is that if those experiments turned out to show the current zone of influence is conservative, they could come back and try to change that.

MR. SMITH: That's a good example.

MEMBER CORRADINI: But it would be one by one? I'm still trying to understand --

CHAIRMAN BANERJEE: Yes. It would be a more controllable process.

MEMBER CORRADINI: Since this is just a for instance anyway I don't, I mean, you haven't seen anything? You've just seen words?

MR. SMITH: This is all we've seen, yes. We've had one presentation on the methodology.

MR. MARKLEY: This is fairly new. It's somewhat of a hybrid outgrowth of the STP pilot.

MEMBER SCHULTZ: And that's the words that were used in the presentation to you, scalable to deterministic methods, use them to the extent possible?

MR. MARKLEY: Right.

MEMBER SCHULTZ: So every one would be different for the staff to review so a case-by-case basis.

CHAIRMAN BANERJEE: Are they going to make a submission for approval of this or what's the next steps?

MR. SMITH: Well, I don't know what they're going to do but I think that these plants are going to come in trying to use a simplified approach. That's my feeling.

CHAIRMAN BANERJEE: But you'd have to prove, I mean, or something that this was feasible. I'm not sure whether it would be a ad hoc approach or a more systematic approach where this alternative approach would be reviewed and then applied in a systematic way or is it going to be another ad hoc thing?

MR. SMITH: I can't tell you how it's going to be implemented. I don't think we got into that much detail with them yet.

CHAIRMAN BANERJEE: Okay. All right, thanks, Steve.

DR. WALLIS: So your staff-approved methods are cast in concrete?

MR. SMITH: If somebody comes in using the NEI methodology as approved by our SE, we will accept that.

CHAIRMAN BANERJEE: All right.

MS. INVERSO: And then on Slide 7 we just have a list of references and the public meeting summaries. If anyone is interested, we can provide those. And that concludes our presentation.

CHAIRMAN BANERJEE: Okay, thank you very much, Tara. If there are no other questions now, we're just ten minutes behind schedule. Thank you.

And we will have South Texas come up. That would be great, and I think Mike Murray will be up leading the discussion, right?

MR. MURRAY: I'll facilitate.

CHAIRMAN BANERJEE: Facilitate the discussion.

MEMBER SCHULTZ: Sanjoy, while we have a bit of a break, just for information are we going to hear proprietary information today?

CHAIRMAN BANERJEE: Apparently not. I asked Mike that and --

MEMBER SCHULTZ: Didn't think so based on the materials that they provide. Good. Thank you.

CHAIRMAN BANERJEE: If it comes up that we have, Steve, we'll just close the meeting --

MEMBER SCHULTZ: Of course.

CHAIRMAN BANERJEE: -- at that point.

There's no problem.

MEMBER SCHULTZ: We have a lot to cover so I wanted to be sure it was well organized.

(Off microphone discussion)

CHAIRMAN BANERJEE: All right, so let's go through this Mike as expeditiously as possible but we will, you know, I don't mind. If we need to take more time, we'll take more time on this, so. This is sort of the heart of --

MR. MURRAY: I understand that and our desire is to be able to answer as many of your questions that you have about the process, how we've applied it, what we've done and to the level of detail that you desire.

We have a lot of detail in a number of our slides -- this is Mike Murray speaking by the way -- a lot of detail in the slides and we can go to the level of detail in those, for example, calculations that you need.

Our intent was more to show you how the calculations were brought into the models and how they're brought into the CASA and then distributed out through the PRA --

DR. WALLIS: Could you give me the overview first? I mean I look at all this stuff and it's full of mathematics but I don't know how big the strainer is, I don't know the size of the holes, I don't know how much debris there is. Could you give me the perspective of what the problem is first so I can understand it?

MR. MURRAY: So you want to go through the introductions first and then we'll get right into Mr. Wallis and we'll get that starting point with that then?

So we'll go through the introductions. We'll have each individual actually introduce themselves. I am Mike Murray. I'm the Regulatory Affairs Manager at South Texas Project. Ernie.

MR. KEE: Ernie Kee. I'm the Technical Lead on South Texas Project risk-informed approach.

DR. HOWE: Kerry Howe from the University of New Mexico. I'm Kerry Howe from the -- It's not on.

CHAIRMAN BANERJEE: It's not on.

DR. HOWE: That on now?

(Simultaneous speaking)

DR. HOWE: I'm Kerry Howe from the University of New Mexico.

DR. JOHNSON: David Johnson from ABS Consulting.

DR. LEAVITT: Janet Leavitt, Alion Science and Technology.

DR. LETELLIER: Bruce Letellier from Alion Science and Technology.

DR. MORTON: David Morton from the University of Texas.

DR. VAGHETTO: Rodolfo Vaghetto from Texas A&M University.

(Off microphone discussion)

MR. RENCURREL: David Rencurrel from the South Texas Project.

MR. ENGEN: Rob Engen from the South Texas Project, Engineering Projects Manager.

MR. BLOSSOM: Steve Blossom, Project Manager, South Texas Project.

MR. HARRISON: Wayne Harrison, STP licensing on the risk-informed GSI-191 project.

MR. RICHARDS: Drew Richards, South Texas Project licensing.

CHAIRMAN BANERJEE: Everybody knows you, Yassin.

DR. HASSAN: Yassin Hassan, Texas A&M.

DR. MOHAGHEGH: Zahra Mohaghegh and Seyed Reihani from University of Illinois.

DR. BLANDFORD: Ed Blandford from the

University of New Mexico.

DR. HASENBEIN: John Hasenbein from the University of Texas at Austin.

MR. MUNOZ: Dominic Munoz with Alion Science and Technology.

MR. UNIKEWICZ: And Steve Unikewicz from Alion.

MR. MURRAY: So what you've seen there is pretty much the technical team and the licensing team that has built this from the start so that was informative discussions.

Want to talk a minute about the meeting purpose, is review the progress since we last met in 2012. We also want to describe the risk-informed treatment of debris.

And then we had a request to do specific examples where we could show pass and fail so we have those in the specific example section, so what we'll have done is lay out the groundwork of the technical input before we get to the examples so then you should be able to apply what we discussed previously into those examples.

In the meeting agenda the way we have it set up is we will discuss the progress since last meeting, general overview. We'll get into the CASA Grande interface with the PRA. We'll discuss thermal-hydraulics and how we've utilized it in our CASA inputs, in-vessel effects, LOCA size and frequency, treatment of chemical effects and then we'll get into discussions on head loss and then our plan is to go into specific examples.

We have a lot of slides. There's a lot of calculations shown in the slides. We can certainly answer questions about it. Our intent was to show the ACRS that there was calculational support for what the CASA model's doing and these are the calculations that are supportive of that. So let's get into answering Dr. Wallis's question.

DR. WALLIS: Yes, because unless you answer my question, I don't know why you're doing this at all.

MR. MURRAY: Then that's what we'll go for right now. Ernie.

MR. KEE: This is Ernie Kee from South Texas. Go ahead.

MR. MURRAY: No, let's get into the question specifically --

MR. KEE: Oh, I'm sorry.

MR. MURRAY: -- about the design of the strainers.

MR. KEE: Okay. So before we've done the plant modifications, one of the major things that we changed out was the strainers. And the previous strainers had, I believe, quarter-inch, I'm looking at Rob Engen, quarter-inch holes and they were very small flowing area. They're just designed basically like you mentioned, your shower drain kind of design.

When this problem got identified, we replaced the strainers with these crenulated design width and they're 1,800 per -- 1,818 square feet so they're just absolutely enormous.

DR. WALLIS: So the total square footage is --

MR. KEE: Three times 1,818.

DR. WALLIS: Eighteen by 18 times three?

MR. KEE: Yes.

DR. WALLIS: Okay.

MR. KEE: Yes, sir.

CHAIRMAN BANERJEE: The hole sizes?

MR. KEE: And the hole sizes were reduced to 0.095.

DR. WALLIS: 0.095 so that's something

over 2 millimeters, 2-1/2 millimeters, something like that. Okay.

MR. KEE: Yes, sir. But we didn't stop there.

DR. WALLIS: And how much debris was there?

DR. LETELLIER: So the maximum double-ended guillotine break can generate a little over 2,700 cubic feet.

DR. WALLIS: Twenty-seven hundred cubic feet of fiberglass?

DR. LETELLIER: That's right, for the largest break.

DR. WALLIS: So this is the several dump truck loads or whatever, the 50 pickup loads or something. Oh, okay.

MEMBER CORRADINI: That's before chemical effects or after chemical effects?

CHAIRMAN BANERJEE: That's just debris.

And that was as current plant, right? So you've removed some of the particulate insulation I noticed.

MR. KEE: We've done some other work besides the strainers if we want to move to the other one.

CHAIRMAN BANERJEE: But the 2,700 cubic feet is mainly fiberglass?

MR. KEE: Mainly fiberglass, yes, sir.

CHAIRMAN BANERJEE: Nukon I take it.

DR. LETELLIER: One other statistic you'll find interesting. The increased strainer size reduced the approach velocity to 0.01 feet per second. So this is a substantially different flow regime from what the previous generation of strainer --

CHAIRMAN BANERJEE: Is that the approach velocity or is there a velocity parallel to the strainer face or is it all one --

DR. LETELLIER: What I'm quoting is simply the perpendicular average velocity.

CHAIRMAN BANERJEE: Okay, but what is the flow velocity past the strainers? Is there a flow past?

MR. KEE: In the pipe?

CHAIRMAN BANERJEE: Well, I don't know. Without looking at a picture of this, it's hard for me to imagine exactly what it is like.

MR. KEE: So those are, I'm looking at Rob again, ten inch. Is that true, Rob, the suction piping? It must be larger than that.

So but it's standard design piping. We

didn't change the piping configuration that went down to the manifold.

MEMBER CORRADINI: But actually Sanjoy asked a question that since we're going to -- And, again, I don't want to get ahead of you. You guys have total control telling us to hold off until it's later.

But, to me, since you're going to get into details, is there a physical drawing of what this looks like so Dr. Wallis can look at something? And if there's a number later on we can look. You don't have to pull it up now but is there a physical geometry?

MR. KEE: Yes.

MEMBER CORRADINI: Okay, that we can look at just to --

CHAIRMAN BANERJEE: Maybe you could bring up a slide which later on is coming up.

MR. KEE: We do. Now, for exact dimension, dimensional drawings and so forth, we don't exactly have that here.

MEMBER CORRADINI: Fine, but we need to know --

CHAIRMAN BANERJEE: A schematic.

MR. KEE: A schematic, sure. We have that. That's coming up very soon.

DR. WALLIS: So the number you gave me, something, 1,000 square feet of strainer, 2,700 cubic feet of debris, so you've got about 2.7 feet of debris all over the strainer if it all comes down?

MR. KEE: If it were 100 percent transported.

DR. WALLIS: So you have a real incentive to do away with the large break, right?

DR. LETELLIER: I wouldn't put it in those terms. We have a real incentive to understand the risk introduced by the large breaks and to mitigate it.

DR. WALLIS: Well, I just put it a different way.

CHAIRMAN BANERJEE: But let's go back. This is 2,700 cubic feet primarily of fiberglass, right?

DR. LETELLIER: Yes.

CHAIRMAN BANERJEE: And the typical calculations you do, much of this would be transported because they would be fairly, you know, fine material. So if it ended up on the strainers, it would be fairly substantial, a couple of feet of this fluffy stuff.

DR. LETELLIER: It is possible but remember that in the zone of influence there are size distributions by mass and we do account for complete transport of the fines into small pieces and then potential erosion of the large blankets.

CHAIRMAN BANERJEE: Okay, so there's 27 cubic feet or whatever, 27. I've forgotten the number.

MEMBER CORRADINI: Just stick with two feet if it all got there.

CHAIRMAN BANERJEE: Yes, so some part of it is just pretty coarse stuff that wouldn't get there, let's say. How much of it does your calculation show would be fines that would get there, fine fibers and fine particulates?

DR. LETELLIER: I'll have to get an exact value for you to answer that question, be precise.

CHAIRMAN BANERJEE: Is it six inches, three inches?

DR. LETELLIER: I'd like to be precise.

CHAIRMAN BANERJEE: Okay. Can we table that, Mark? This is a question.

MR. MURRAY: We got that. So what I'd like to do, if we could, is get into the presentation because I think some of the answers for what we're asking are jumping forward into and we should be able to lay out some of it. And then if those gaps are still there, bring those to us and we'll make sure that we get those gaps filled.

CHAIRMAN BANERJEE: Mike, the only thing that might be helpful is if you have a slide sometime in the future which shows a schematic of your layout of the strainers and what they are, that would be helpful for us right now to place everything in context in our minds.

MR. KEE: Yes, sir. Do we want to go to that picture?

CHAIRMAN BANERJEE: Just show one picture.

MR. KEE: It's just what is --

MEMBER CORRADINI: Tell us where. We've got all this paper.

CHAIRMAN BANERJEE: We've got all this paperwork. Is it Slide 29 or 72 or what?

(Off microphone discussion)

DR. LETELLIER: Another common reference source, if any of the Members happen to be holding Volume 3 of the submittal, that'll be a common reference for answering questions.

CHAIRMAN BANERJEE: Okay, we have it on.

DR. LETELLIER: There are photographs provided as well as the floor layout.

CHAIRMAN BANERJEE: But right now I guess

60, no.

MR. KEE: Page 21.

CHAIRMAN BANERJEE: 21?

MR. KEE: Yes, sir. So that's a very schematic schematic but it does show how the flows are pulled through at the South Texas Project. There are independent trains, three trains, of ECCS and there's a total amount of flow that is pulled through the strainer.

And someone mentioned containment spray. So one of the things that we've done is secure a containment spray pump when we have otherwise successful on the other two trains in order to reduce the total flow through one strainer. That helps on the pressure drops. And it also reduces or increases the time to emptying the refueling water storage tank.

And then the flow, that total flow gets fractionated as shown. That's gamma. The fraction of the total flow that goes to the reactor coolant system is identified as gamma times the total flow.

And that further gets fractionated by a lambda that would be going into the core and 1 minus lambda would go out to the sump again and return to the sump which is shown there. It's identified as P. The nomenclature -- I forgot. We put the nomenclature on the right.

MEMBER STETKAR: Ernie, you guys obviously have a big show organized here so stop me. You mentioned something that kind of piqued my brain cells a little bit.

The plant has procedures where you shut off, if you've got all three containment spray trains running, where you shut off one spray train. And the plant also has procedures that when containment pressure gets down below about 6-1/2 pounds, if I remember correctly, you shut off all spray.

MR. KEE: Yes, sir. That --

MEMBER STETKAR: Okay. As I understand it, the CASA Grande models assume that all of those actions are always performed perfectly. The PRA models assume that all of those actions perfectly fail.

So when we talk about the interface between CASA Grande and the models, the PRA models, I'd like to understand how those fit together because it sounds like the PRA models have a lot more flow going to things than the CASA Grande models which in some sense might be good, in some sense might be bad.

On the other hand, it sounds like the CASA

Grande models are assuming operators are always 100 percent absolutely perfect at the times when they, by procedure, are supposed to be 100 percent absolutely perfect which sounds woefully optimistic, so.

DR. JOHNSON: Let me jump in. This is David Johnson. You're right that we assumed both in CASA Grande and in the PRA that the operators were perfect on those two points.

MEMBER STETKAR: In the PRA I read that you assumed that they were absolutely not perfect. The split fractions are failed.

DR. JOHNSON: Well, they're failed but meaning they did turn off the third train of spray and they turned off all trains later on.

MEMBER STETKAR: Oh, so the definition of those type events as it's described in the PRA is confusing or wrong.

DR. JOHNSON: No, it's not wrong. It's correct as stated but it's worded a bit strange. And this was the subject of an RAI the staff's had and part of the discussions a couple weeks ago, and we recognize that we need to put the operator actions into the model. The PRA has those branches. We just don't have CASA Grande results to match up with them.

So we'll either take a very conservative view of failure of those two actions going forward or hopefully have CASA Grande results to match up with it. CASA and the PRA align nicely with each other.

MEMBER CORRADINI: I'm going to jump you back unless John had a follow-up.

MEMBER STETKAR: No, I was just looking for --

MEMBER CORRADINI: Okay, so you gave us a schematic. I've looked through the tome. On Page 104 and 107 there's CAD drawings which at least give me a feeling for where stuff is. Is that the best we've got today?

DR. LETELLIER: No, we can pull up Volume 3 and give you a photograph.

MEMBER CORRADINI: Okay. But on the list that everybody's got in front of them right now, 104 and 107 has indications of where stuff is.

DR. LETELLIER: Yes.

MEMBER CORRADINI: Okay, fine.

DR. LETELLIER: The schematic is accurate to the sense that the manifold's set at the containment pool level. They are not recessed in a cavity and all of the trains are collocated on one side of containment.

DR. WALLIS: Can I comment on this figure? It's very helpful and I also looked at some of your analysis that you sent. Everything seems to be based on the mass of stuff, how much mass of various things go somewhere.

But all the evidence about performance of strainers and so on indicates that mass isn't the real determinant. It's what the stuff is made of, I mean the size distribution of the particles, the size distribution of the fibers and so on. Makes all the difference in the world. So mass by itself is not an adequate deterministic of what's proper to specify. You'll say more about that, right?

MR. KEE: Yes, sir. But the mass, all the species that arrive at the strainer are being tracked. Now, we could discuss, you know, how they are characterized. We agree on that, but those are all --

DR. WALLIS: Well, to enlarge on my point a bit, I mean different LOCAs produce different size fiber distributions, different fibers in there.

MR. KEE: Yes, sir.

DR. WALLIS: If the fibers are close to the burst pipe, you get very fine fibers. If the fibers are farther away, maybe you get fibers which are centimeters in length.

MR. KEE: Absolutely.

DR. WALLIS: So you got a tremendous variety of size distributions of these fibers and sometimes maybe there's a small break which happens to be close to some fibers. It's worse than big break which is far away from the fibers, so there's a whole spectrum of stuff. Do you consider all that in your analysis?

DR. LETELLIER: We do to the extent that the zone of influence is fractionated into nested zones that account for those fractions.

DR. WALLIS: But then the fines are also characterized by length? If you have fibers which are all less than 2 millimeters in length, they all go through the strainer, don't they? So it depends on how small they are when they're broken up.

DR. LETELLIER: So the mass fractions are based on analyses of debris jet testing, sometimes surrogate information.

DR. WALLIS: Do you have tests on the fiber length distribution produced by jets different distances from fibers and fiberglass and so on?

DR. LETELLIER: No, we do not. We have

industry consensus on fiber preparation for surrogate testing.

DR. WALLIS: But that, you see, that's one of the problems I have with this whole thing. There's an industry consensus on lots of things which doesn't seem to -- I don't know what supports it.

CHAIRMAN BANERJEE: Well, I guess the question Graham is asking, if you put it in a slightly different way, we've accepted certain things which are, like, industry consensus because they were applied to bounding calculations. That's the reason we've gone along, at least ACRS has in general.

Now, if you start to use that consensus as the basis for, you know, distributions and surrogates and all that stuff which was meant for these bounding calculations, then we need some understanding of how these carry over to the sort of calculations we're doing and I hope you make that connection for us.

DR. LETELLIER: We do understand that, that apprehension, and to the maximum extent, I won't say maximum extent, but we have adopted the deterministic assumptions with regard to the sizes involved.

DR. WALLIS: Well, I'm sorry but bounding is not good enough for me because what's bounding for one thing is not for another.

If I have very long fibers from a weak LOCA, they all get stuck on the strainer. None go to the core, and that's a bounding thing for the strainer maybe.

If they're chopped up into lengths less than 2 millimeters, they all go through the strainer. They all go to the core. That's another bounding limit, quite the opposite, you know?

So and then there's a whole distribution in between which affects the strainer and the core differently. You can't set up a bounding distribution of fiber lengths.

CHAIRMAN BANERJEE: Well, I think we'll come back to this later. Why don't we go forward. You have a point, John, or --

MEMBER STETKAR: Yes, just quick because it'll help me, perhaps, later. If you look at, this is for Dr. Johnson, if you look at Section A.4.1 of the PRA description, if I look at top event OSI it says, "This new top event represents a manual operator action to secure one train of containment spray, if all three are running, to conserve RWST water."

"For the current GSI-191 project, this

action is always assumed failed within the PRA model; i.e., split fraction OSIZ=1.0 is always used. However, within the CASA Grande, this action is always assumed successful when determining the failure probabilities introduced by the GSI-191." Hence, my confusion.

DR. JOHNSON: Okay, and I understand your confusion. The text --

MEMBER STETKAR: Okay. We should go on.

DR. JOHNSON: The text is wrong, so we do align this area, CASA align.

DR. LETELLIER: Just a quick comment. CASA models the time to success and the PRA handles the failure if that performance is not successful.

MEMBER STETKAR: Okay, but CASA never accounts for the cases wherein either that action or the other one to shut off all spray has failed.

DR. LETELLIER: We account for the delay and within the calculation time it can be a rather long time as sampled. But, in essence, we do assume it's eventually executed.

CHAIRMAN BANERJEE: Okay, now that we've seen the layout in rough terms, we can move on.

MR. KEE: Oh, yes. We should probably move quickly through this. We've done --

MR. MURRAY: Ernie, let me point out one thing. So during the break, we'll look at Volume 3. We'll look at a better picture, pictorial of the strainer and after the break we'll bring it in and display it and can answer the questions about the strainer.

CHAIRMAN BANERJEE: Let's go on.

MR. KEE: So it's been mentioned -- This is Ernie Kee speaking, I'm sorry -- previously. Now is this going to work for me?

MR. MURRAY: Yes, sir.

MR. KEE: Okay. We did perform three quantifications associated with submittals, the final one in November of 2013.

Some other work that we've completed is, besides what's above, is sensitivity studies which were a subject that was asked for by this Committee in 2012. So we developed a methodology and completed some studies along those lines and we'll have results from those.

And then we also went ahead and did some confirmatory tests to show what we would expect to see if we had a blender, these fine particles that Dr. Wallis is mentioning, what would the effect be if we had those kind of particles all on the debris bed on the strainer?

What would that look like?

And so those were, we call those overloaded tests and we're going to discuss those later. And we repeated the large break LOCA test with these fine debris beds on them. We've done a lot of work in thermal-hydraulics. A good body of work's been done there.

We've developed engineering analyses that support some of the assertions we make with regard to, I'll call it safety factor or uncertainty with our head loss and chemical effects.

We've also done strainer bypass testing to see how much of the particulate does penetrate and go through the strainers with the small holes.

Some of the thermal-hydraulic results have shown that the hot leg breaks and small breaks go to success with regard to full blockage with both the core and the core bypass blocked totally, 100 percent.

Then we also have done, the additional testing tends to indicate that there's very little precipitate formed in the post-LOCA fluids at South Texas Project.

MEMBER CORRADINI: So can I ask a question?

MR. KEE: Yes, sir.

MEMBER CORRADINI: Since this is risk informed, there's a probability with that conclusion, right?

MR. KEE: With which conclusion?

MEMBER CORRADINI: Well, all of them. I mean you're telling me sensitivity show that the fiber loading is 7-1/2 grams per, blah, blah, is risk-dominant threshold with a probability of X. So then the next question that John's going to ask you is show me the uncertainty band on X.

MR. KEE: Yes, sir.

MEMBER CORRADINI: Okay, so that I can then say that 15 is at the -- I mean where I'm going with this is I'll accept this for now but eventually we're going to show some sort of curve since you guys went through all the effort of putting distributions in all this stuff and grinding through the calculation.

MR. KEE: Sure. Yes, sir, and we've talked about adopting industry deterministic results, so this is an excellent example where we've adopted a result that was obtained with -- The PWROG actually did testing on all fuel types and found that cooling was adequate actually at 15 grams per fuel assembly including full chemical effects and all the particulate which we don't believe would tend to be transported to the core because there would be fiber on the strainer which would tend to collect particulate. So this is an example of a deterministic application within --

DR. WALLIS: So if I see tests from another place which showed significant blockage, I mean complete blockage with 15 grams, I should ignore that because you did some tests which showed it was okay?

CHAIRMAN BANERJEE: No, they didn't do any tests. They're just adopting the --

DR. WALLIS: We've seen evidence from all kinds of places that you may have not seen, you know?

CHAIRMAN BANERJEE: If I understood what you said, that 15 grams is assembly particle to fiber Issue 1 or whatever it was. I forget now. It doesn't matter, but the reality is that there is a staff-approved limit there and what you're saying is you're below that?

MR. KEE: Yes, sir.

CHAIRMAN BANERJEE: That's really --

MR. KEE: Yes, that's the point.

CHAIRMAN BANERJEE: That's the point.

DR. WALLIS: Fifteen grams is the staff-approved limit.

MR. KEE: Yes, sir.

CHAIRMAN BANERJEE: Which we agreed to as well. We wrote a letter saying it was fine.

DR. LETELLIER: If I could respond to Dr. Corradini's observation, as a pilot project for the risk-informed resolution, we're forging new definitions of probability distributions in combination with deterministic methods.

And so it would be my desire to risk inform every distribution but some of those factors have been accepted by the staff and they're probably not worth challenging at this point.

MEMBER CORRADINI: Sure, that's fine but, just, and then we should move on, I'm not misunderstanding. When you say that, there's a probability with that which there's an uncertain band on that -- Okay, fine.

DR. WALLIS: Could I ask you what you mean by Number 1 there, by small cold leg break?

MR. KEE: Yes. The definition of a small cold leg break is anything from, I don't know, an eighth of an inch up to two inch.

DR. WALLIS: So anything above two inches gives you a problem?

MR. KEE: Yes, sir. In a cold leg break situation -- That's true? Two to, yes. For a medium break LOCA --

(Simultaneous speaking)

MR. KEE: Yes, and we should say those are a challenge.

DR. WALLIS: Are you going to explain why that is possible with sump switchover? You don't switchover to -- You pump in from just the bottom of the core, not from the top? Can't you switchover the way that you pump in your long-term coolant?

MR. KEE: Yes, sir and, indeed, we do that.

DR. WALLIS: Doesn't that cure this problem of the two-inch break? Cool it from the top after a while?

MR. KEE: Oh, we don't have a problem -- Oh, above two inches on cold leg breaks.

DR. WALLIS: Yes. Why don't you just switchover the injection to them? Doesn't that cure the problem?

DR. LETELLIER: Yes, it does.

MR. KEE: Yes, sir, but this, yes. So and then Rodolfo, yes. That's true, yes.

DR. WALLIS: So there is? So why don't you use that? Say that you're okay for all breaks because you can just switchover injection if you have a cold leg break.

DR. LETELLIER: The challenge exists up until the time of recirc but because our model is time dependent, we need to be cognizant of the failure modes that can occur before that switchover occurs.

DR. WALLIS: I see. But you could switchover earlier?

DR. LETELLIER: That is an option if the EOPs were changed and, in fact, that's the value of having this quantitative model, is to help us make those choices.

DR. WALLIS: And that would be in the procedures presumably. If they do have trouble, they switch out.

MR. KEE: I think maybe we're confusing some terms here. So just to be clear, when we refer to hot leg, when we refer to switchover, sump switchover, that means when the refueling water storage tank, 500,000, 600,000 gallons --

DR. WALLIS: Start recirculation.

MR. KEE: Then you switch to that sump pool we showed where the strainers are located. That is the time at -- So for large break LOCA, just to give some time frames, that's roughly 20 minutes to a half an hour into the scenario and at that time our assumption in the thermal-hydraulic analysis is that the core's, and the core bypass, there's no opportunity for flow to go up.

And now that, I mean, it's an instantaneous blockage which clearly will not happen so we view these as, I refer to them as extreme cases to kind of screen out cases that we don't need to expend a lot of effort on.

(Off microphone discussion)

MR. KEE: Yes, sir. Sorry. And then --

CHAIRMAN BANERJEE: All right, let's go on.

MR. KEE: Yes. And strainer testing where we developed observations on how much fiber actually penetrates through the strainer and sheds.

DR. WALLIS: Are you going to describe those tests for us? Or Bruce will maybe.

DR. LETELLIER: We are not discussing those in detail but in your earlier conversation you correctly identified that as an important consideration.

DR. WALLIS: Well, how do you prepare the fibers for testing?

MR. KEE: How do we prepare? It's a NEI protocol.

DR. LETELLIER: Right. As I said, there's an industry consensus to use --

DR. WALLIS: But I disagree with that because it seems to me you just throw them into a blender and churn them up and there's no relationship from what comes out to what comes out in the LOCA so I can't make the connection, right?

DR. LETELLIER: I can't respond to that directly. The staff may have opinions.

DR. WALLIS: Well, the staff doesn't seem to see it as an issue either so I just say, well, I mean, I'm not convinced, okay, so --

CHAIRMAN BANERJEE: I think that's different.

DR. LETELLIER: We might offer that the NEI-prepared fiber has been extensively characterized.

DR. WALLIS: I understand all that. Yes, I know that but --

MR. KEE: No, it's a fair question.

CHAIRMAN BANERJEE: Well let's, you know, one of the things, of course, we will be interested in this Slide 8, is the strainer testing that was performed to quantify the filtration efficiency and shedding rates. Clearly that's going to be a key phenomenon.

MR. KEE: Yes, sir, yes.

DR. LETELLIER: And we have examples that illustrate that.

MR. KEE: We'll show that later.

CHAIRMAN BANERJEE: And that, as Dr. Wallis says, is very dependent on the fiber characteristics and the particles you use and all that sort of stuff.

Generally when you have very large area strainers with very small amounts of fiber getting there, a rough rule of thumb we are used to is about 50 percent of it goes through, you know, sometimes a bit more.

DR. LETELLIER: Our calibration shows about 63 percent and it's a function of the mass loading on the strainer and it also accounts for long-term shedding or migration.

CHAIRMAN BANERJEE: So that=s in line with what we have seen in the past. In any case, we'll revisit that as we go.

MR. KEE: Yes and I think our testing's

consistent with your observations.

And then, thus, we now just want to talk about, start a very high level. So I don't think we need to spend a lot of time here but just to review the context.

We are doing what's called a risk-informed analysis here. And what we have already mentioned that we've done in the plant is made modifications that we believe will lead to safe operation, continued safe operation and those have been done.

We removed the, I want to say nefarious insulation types, for example cal-sil, and we've changed our design change process so that we're required to review what goes into the plant and make sure it's not going to raise any concerns associated with GSI-191.

We've modified procedures, containment cleanup, so on and so forth, and we've mitigated welds that are susceptible to the degradation mechanisms that we understand and know. So there's been a lot of work done that we believe leads to safe operation of the plant.

But the question remains, is quantitatively what is the effect of these changes that we've made? And so we followed this process where we use the PRA to evaluate what is the residual risk associated with any of the concerns raised in GSI-191?

And we had a path defined where, you know, if we found the risk to be high, very high I'd say, we would go in and try and figure out what kind of further modifications we would have to do. And obviously the risk is high enough that we wouldn't even consider using this kind of an approach.

We think there's a middle ground possibility where the risk is high but we could identify. That's the advantage of doing a risk-informed analysis. We could identify some changes either in the plant or, perhaps, in the analysis with some of these bounding kinds of assumptions that would let us go in and reevaluate the risk and find where we stand. And then if it's very small, and we're talking very small numbers here, then we would submit a license amendment request.

What we had to do in order to support that -- I'm sorry. That's Slide 11. We'll be mentioning that.

DR. WALLIS: So your bottom line is that you predict delta CDF of 3 x 10^{-8}?

MR. KEE: Yes, sir. And I'm referring

back -- Well, the numbers are there for CDF and LERF.

DR. WALLIS: I'm asking you because I had difficulty finding the bottom line in all the stuff that you sent me.

MR. KEE: I'm sorry. Yes, the bottom line is we want to understand the risk that may be associated with this and understand that we continue safely operating.

So in order to attack this problem, we did what was called a risk assessment that required us to replace in one case the commonly used sump demand failure probability with a well-supported, peer-reviewed engineering analysis.

And that involves uncertainty quantification so we quantified the uncertainty throughout that, propagating these models with their inputs and outputs as they are linked. And I just want to --

CHAIRMAN BANERJEE: You're going to expand on some of these points later on?

MR. KEE: Yes, sir.

CHAIRMAN BANERJEE: Right.

MR. KEE: Yes, sir. Yes, we can.

MEMBER STETKAR: In particular for this

afternoon make sure you talk a lot about how you developed the uncertainty distributions from CASA Grande. If you're not ready to do that, be ready to do that this afternoon or take notes.

MR. KEE: And, again, someone asked about the processes that we followed. Doing this we used existing plant procedures, processes and programs that we commonly use for most other risk applications and adopt the industry, we do follow the industry standards for regulatory application of the PRA and for quality.

Just another high-level picture here is to kind of build on what I just said. We have kind of viewed this problem in two pieces where we've developed some conditional failure probabilities that are supplied to the PRA.

And they could be thought of as basic events or top events but they are supported not by, obviously, statistics on performance but by engineering analysis, that basically a lot of it is we've recast several of these industry models that we've mentioned before, the ZOI for example, or this fuel loading number. We've adopted those in a risk framework.

MEMBER CORRADINI: So can I say it differently?

MR. KEE: Yes, sir.

MEMBER CORRADINI: Certain pieces of the calculation, if I were to run through and do essentially a deterministic calculation on the way, there are certain inputs that have distributions. There are certain inputs that are delta functions that are just essentially chosen to be what you, we'll call it bounding, assumed, agreed upon, whatever.

MR. KEE: Yes, sir.

MEMBER CORRADINI: And but you run through the calculation. Certain things have distributions. Certain things don't.

MR. KEE: Correct. Yes, sir.

MEMBER CORRADINI: Okay. And back to Graham's point or at least issue I guess, is that certain of those things are based on guidance that might be okay in a conservative calculation but might be challengeable.

MEMBER STETKAR: But from what Graham said, fiber size is not one of those things that has a distribution.

MEMBER BLEY: From your response to it --

MR. KEE: That is correct.

MEMBER BLEY: -- and from what we saw in the experiments, that was pretty key. So I'm a little confused of --

MEMBER CORRADINI: What they said was it was formulaic. They assumed what was the mix.

(Simultaneous speaking)

MEMBER STETKAR: But, I mean, in a risk-informed approach they picked a number basically. They didn't pick an uncertainty distribution.

MEMBER BLEY: That might not be, unless you can convince me, might not be conservative, if you will, for all cases that you're looking at.

DR. LETELLIER: We need to examine the specific assumptions about how we treated the size fractions but I do agree that we're focused on a single formula of debris preparation that's been highly characterized and our assumptions in --

MEMBER BLEY: And kind of negotiated for the purposes of the tests that were being done. I mean, it isn't really the way, in my mind, I'd formulate a probabilistic approach to this problem if, in fact, that's a key parameter and I kind of think it is, but go ahead.

DR. LETELLIER: I would like to add that Dr. Wallis points to the bottom line of about 3×10^{-8}

as delta CDF. That does include some failures from large break events and it is weighted by their probability of occurrence exactly the way you inferred.

DR. WALLIS: So the large break is the main contributor to the CDF?

DR. LETELLIER: So far it's the only contributor. Large break LOCA's greater than six-inch breaks.

DR. WALLIS: So that's the key to the whole thing, isn't it?

DR. LETELLIER: I think part of the key is understanding why those scenarios fail and prioritizing the actions that can be taken to monitor or mitigate.

DR. WALLIS: Well, you have to believe the probability curves that we heard about some years ago for large breaks. You have to believe the probability is as low as shown in those curves.

DR. LETELLIER: That's true. That's true. The initiating of that frequencies and their uncertainties are the start of the whole calculation.

MEMBER CORRADINI: So if I were to ask Graham's question, the reverse, how much off would you have to be to go from acceptable to unacceptable? I mean that's what I think would be the next question, is you think it's here but it's not here, it's higher? How much higher?

DR. LETELLIER: So we have addressed that question.

MEMBER CORRADINI: That's fine. Then we'll wait. If you have, we'll --

DR. WALLIS: Have addressed that, yes.

DR. LETELLIER: Using sequential parameter studies you can answer your question with any single variable and we've looked at it from the point of view of uncertainties and initiating event frequencies and some of the principal drivers in the physical models so that we do understand those margins for failure.

For example, I can give you a quick example. We've already talked about the 7-1/2-gram limit but that is our baseline and we accept the 3×10^{-8}.

If we were to reduce that to a five-gram limit, then our risk would increase by a factor of almost six. If we decrease that to a four-gram threshold, then our risk increases by a factor of 100. On the high side, if we increase it to twice, to 15 grams per fuel assembly, we have about a 30 percent increase.

DR. WALLIS: Could you say how much this is in total? How many assemblies are there when you multiply 7-1/2 by whatever the number is?

MR. KEE: One hundred ninety-three.

DR. WALLIS: So there's 200 x 7.5 so that's whatever.

MR. KEE: That's right.

DR. WALLIS: Fifteen hundred grams and how many grams start out in this 2,700 cubic feet? How much do you have to remove to get down to that? You have to remove one -- You come up with one part in 1,000, one part in a million. What do you come up with in the end?

MR. KEE: So what we find actually is, and there's probably enough people in here that can correct me if I'm wrong, but unless you're very careful, like, very, very clean containment of the latent debris, which we take into account, is sufficient to achieve that level. Now --

DR. WALLIS: That's what puzzles me because other plants that have no fibers still have a problem with latent debris.

MR. KEE: I can't speak for other plants but, yes, sir, that could be a problem. I want to say something about, and we've talked about this in a RAI response, that 7-1/2 grams on a fuel assembly.

And I'll show you a picture later of how the details of the, well, it's a schematic of the inside of the vessel, what that looks like. So if you put all 7-1/2 grams on fuel assemblies, it turns out there's all kinds of other places water can go to cool the core.

Yes, so in some sense we've overestimated the risk associated with this problem and maybe in other cases we can argue that maybe, as you bring up, the debris characterization, that may change it in another direction. But the bottom line is the risk is very low that we quantify with the way we're doing it.

DR. LETELLIER: We've talked about the 7-1/2-gram limit but we actually have a set of plant performance measures that we track throughout a scenario and we're calling these thresholds of concern because as we start to challenge these thresholds you just don't want to cross the line. That implies a risks base that you don't wish to enter. However, there is safety margin present in those definitions.

Now, as Ernie said, even if we block the core to 7-1/2 grams, there are alternative flow paths and opportunities for success. We don't consider that additional opportunity.

DR. WALLIS: Do you know the weight of this stuff by cubic foot?

DR. LETELLIER: It's 2.4.

DR. WALLIS: 2.4 --

DR. LETELLIER: -- cubic feet, pounds per cubic foot, as --

DR. WALLIS: -- pounds per cubic foot. So you start off with 6,000 pounds and you end up with three pounds? You got to remove, you know, you've got to get down to one 2000ths of what you started with to meet the 7.5-gram limit and if it's very, very finely chopped up, that's a pretty tall order.

DR. LETELLIER: It is. We will, hopefully, examine the effect of the filtration function and look at its importance in a couple of cases where it either does by random sampling, the fitted parameters, it either was successful at filtration within the six-hour window or it was not successful at filtration.

DR. WALLIS: So you can remove, so that you remove, you're down to one out of 2,000 you started with. That's a very good strainer for any application, right?

CHAIRMAN BANERJEE: Well, it's not just the strainer. I mean, things are fluffing out.

DR. WALLIS: Yes it is with everything

else, everything else, but you're assuming that everything's mixed up in the sump so it goes to the strainer which is a huge assumption.

CHAIRMAN BANERJEE: Why don't we move on and let --

DR. WALLIS: Well, I need to get this perspective though because, you know.

CHAIRMAN BANERJEE: Yes, but this perspective is going to be repeated later on, right? I mean, but --

DR. WALLIS: I think you should start with the perspective. Say this is our problem. And if you were a student presenting it to him, you said this is the problem. This is how we solved it. So I'm trying to get at the problem. That's why I'm asking this question.

CHAIRMAN BANERJEE: It's about 1 and 10^{-3} roughly because 15 grams is probably okay let's say, so roughly that's what the function has to take out. Okay, let's --

DR. WALLIS: Yes, let's move on.

CHAIRMAN BANERJEE: With the PRA, what's going on? Tell us.

MR. KEE: Yes, sir. So we pass to the PRA.

As I already mentioned, these conditional failure probabilities, and actually it comes down to five of them.

And, of course, we mentioned already the 15 grams per fuel assembly, that that was the measured value for cooling. We've reduced that by a factor of two and we take that as a sufficient flow to continue to allow dilute water to come into the core in a cold leg break to mix with the --

CHAIRMAN BANERJEE: Why do you reduce it by two? I don't understand that. I'm trying to struggle with that.

MR. KEE: Well, that is probably from a historical perspective really. As I mentioned already, there's a lot of uncertainty or bounding assumptions that go into that, the 15 grams per fuel assembly, but there has been comments talking about taking credit for lower plenum mixing for boron precipitation. We don't take credit for lower plenum mixing for boron precipitation so we --

CHAIRMAN BANERJEE: So it's related in some way to boron?

MR. KEE: Yes.

CHAIRMAN BANERJEE: The lower limit?

MR. KEE: When we started this problem, that was separated actually from the considerations of GSI-191, and after the first year of work we completed, it got introduced as another concern associated with GSI-191.

CHAIRMAN BANERJEE: I think you've answered my question. I see where it's coming from. Okay. Keep going now, please.

MR. KEE: Yes, sir. And then at the sump we look for loss of net positive suction head margin, collapse from build-up of fiber to the point where the strainer fails mechanically and then voiding that would cause the pumps to cavitate and, again, these are all incipient conditions.

MEMBER STETKAR: Ernie, you going to talk more about that later on?

MR. KEE: Which one?

MEMBER STETKAR: NPSHA calculations.

MR. KEE: Yes, sir.

MEMBER STETKAR: You are? Okay.

DR. LETELLIER: Yes, in the example problem.

MEMBER STETKAR: Fine.

DR. WALLIS: What do you do about the

distribution of debris on the strainer? The strainer's big thing and the distribution of it is not going to be uniform. There's all kinds of possibilities. How on earth do you handle that?

MR. KEE: Of course, it's possible for it to -- Now, the strainer design that we have purchased is designed actually to uniformly load. That was an objective of the design.

DR. WALLIS: So is it going to cooperate and uniformly go in?

MR. KEE: Well, maybe this will be very instructive when we see the floor of the containment. You'll also see that it's difficult for the debris to arrive on all the strainers equally.

DR. WALLIS: That's right. That's right.

MR. KEE: There's blocked up places that it has to go around and so forth. So, now, if it doesn't load, if it loads differentially, then that would provide opportunity for flow to go through more easily, right? So I actually think that --

DR. LETELLIER: So from the point of view of differential pressure drop, we've assumed that a homogenous, contiguous bed is conservative compared to gaps heterogeneous mode from the point of view of delta

P.

We have the strainer filtration testing using an actual module from the South Texas plant to baseline our filtration model against different combinations of initial concentration and debris arrival. So we do have that combination of assumptions.

MR. KEE: And, in fact, this is anecdotal but the test, and people have been testing these strainers for a long time now and they observe that if you load them up at some point they kind of create a, they call them bore holes and then all of a sudden the pressure drop decreases. And so whenever you see that happening, differential loading like that, then it tends to reduce --

DR. WALLIS: Well, it reduces the --

CHAIRMAN BANERJEE: I want to get through this --

MR. KEE: Sorry.

CHAIRMAN BANERJEE: -- because John has to leave for a meeting with the Commission.

MR. KEE: Okay.

CHAIRMAN BANERJEE: And we need to get through this part and he has to leave at 10:15 so we've got 15 minutes, I mean, five minutes, sorry.

DR. WALLIS: Can I just say one thing?

MEMBER STETKAR: It's Banerjee time.

(Laughter)

CHAIRMAN BANERJEE: We've got to get whatever we can done on these process steps in the next five minutes.

MR. KEE: We'll come back to you tomorrow.

CHAIRMAN BANERJEE: Yes, all right.

MR. KEE: Yes, sir. So these next few slides are just a high-level view of one run through of the uncertainty quantification and just what takes place to set ourselves up to obtain these masses and failures.

So the first thing we have to have is the plant state, so what kind of pumps, trains, equipment's operating? That sets the relationship with the PRA.

We randomly select a weld type/case, we call it weld type, based on their frequency of occurrence and we need to identify these because we are taking into account the possibility of welds that have higher susceptibility to degradation and so forth.

We randomly select the specific weld from that type and case and that locates now in space in the containment where we are and I will identify all the targets that are available.

We sample condition along that weld/case, the frequency of failure and obtain the diameter of the break. Once we know the diameter of the break, break size --

DR. WALLIS: I didn't understand this weld bit. On the large break, the guillotine break isn't a weld break. It's a pipe busting, isn't it?

MR. KEE: But we know about, everything we know about failures, they're circumferential at the weld due to I believe now --

DR. WALLIS: But the assumption in 46, you know, is a double-ended guillotine break. It doesn't say anything about a weld.

MR. KEE: Yes, sir, but those are, well, we can talk about the spatial resolution and so forth but we assume, based on industry experience really, that where we see failures is not in the pipe forging but in the, well, actually at the end of the heat-affected zone and --

DR. WALLIS: Yes, just it seems to be different from the assumptions in 50.46.

DR. JOHNSON: You can think of the welds as just surrogates for location in space and the sampling of 700 and some places in the piping system that could break, so they're just targets.

MEMBER STETKAR: Yes. I mean basically what they do is anything bigger than six inches is called a large LOCA. You can get a six-inch not double-ended guillotine, you know, hole in a 28-inch pipe or you could get a 28-inch hole in a 28-inch pipe. Both of those are in there.

MR. KEE: So once this diameter is sampled, then now we know what size break we're dealing with and that is a PRA branch. And then we also from that know, based on our analysis, the temperature profile that the sump will experience throughout the break history.

Then we calculate from knowing the break size using this, somebody's already mentioned, for the different insulation targets so paint and so on and so forth, a radius of zone of influence they call it. We write this in particular for the fiber debris, for the insulation targets, the three shelves where we can experience damage.

And where it's near the break, of course, there's much more energy so they are broken up, whatever got hit gets broken up more finely than farther out.

It's less finely and then farther out it's even less finely broken up.

CHAIRMAN BANERJEE: Use just the sort of existing staff guidance on this, what we accept, right? There's nothing --

DR. WALLIS: It's different.

CHAIRMAN BANERJEE: -- different?

MR. KEE: It's an accepted, yes, sir. Exactly.

CHAIRMAN BANERJEE: All right, that's fine.

MR. KEE: And you can see here that we have all the types. The L is everything in insulation.

CHAIRMAN BANERJEE: I mean we've had discussion of this many times and we don't necessarily completely agree, as you know, looking at base status B

(Simultaneous speaking)

CHAIRMAN BANERJEE: -- but we have accepted it.

MR. KEE: Yes, and this just shows the nomenclature in kind of a pictorial that illustrates the fact that where there's, and we only take credit in our current submittal for the presence of a concrete, substantial concrete wall or something like that, a structural member that's made of concrete that would cut off the break because that's --

CHAIRMAN BANERJEE: There's new industry testing going on or was going on, I haven't followed it, which was to maybe change some of this a little bit, but you haven't taken any of that into account?

MR. KEE: No. In fact, we did studies to, we started down that path but we found that this zone of influence made the amount of fiber -- Like we mentioned, a very small amount is problematic.

So the influence of the quantity of fiber, by the time you, and like I mentioned, we don't take into account the presence of, like, a reactor coolant pump some or a steam generator, some substantial piece of equipment also blocking off the progress of the jet.

But, yes, we looked into that and we haven't pursued a reduced order model like have been thought of in the industry. We have substantial groundwork in that area.

DR. LETELLIER: You should recognize that there are inherent uncertainties there even with that accepted what we might call --

CHAIRMAN BANERJEE: Oh, sure,

uncertainties, yes.

DR. LETELLIER: Okay, and we're not challenging that or attempting to quantify it at this time.

CHAIRMAN BANERJEE: Okay.

MR. KEE: Yes, sir. So, again, we've adopted in this. Then if the diameter of the failure that we sampled is greater than roughly 30 percent of the circumference, we say that's a double-ended guillotine break. It goes to the whole separated double-ended break situation. Otherwise, it's at the size that we sample and that produces a hemispherical rather than a spherical zone of influence.

And then we can calculate, with that information, we can calculate the mass of debris that's within the target zone of the ZOI and then we applied. Now, when we talked about, well, there's so much generated and so much arrives in the sump and so we have a logic diagram. We'll talk about this just as --

CHAIRMAN BANERJEE: How do you get this F transport?

MR. KEE: Yes, sir.

CHAIRMAN BANERJEE: You're going to talk about that later?

MR. KEE: Yes, sir. We will.

CHAIRMAN BANERJEE: Okay.

MR. KEE: We'll show an example, at least one example.

DR. LETELLIER: These are standard assumptions based on old testing from the BWR drywell debris transport tests, again, standard approach.

MR. KEE: And then we introduce some, and we'll talk about this, but some of the debris. For example, latent debris is immediately put in the sump and some unqualified coatings as well --

DR. WALLIS: What is crud particulate?

MR. KEE: Yes, sir. So basically corrosion products in the reactor coolant system.

DR. WALLIS: Does oxide come off the fuel during these large break LOCAs when you have a temporary, a flow violence and a lot of overheating and stuff? Doesn't it shed some of its oxide?

MR. KEE: Yes, sir. It could. Actually, well, depending upon the LOCA, right? So the worst one typically stagnates the flow in the core, right? So you might not expect that to happen there. But in other break situations, maybe you would have an expectation for that and we --

DR. LETELLIER: We assume a fixed amount that's a maximum inventory.

DR. WALLIS: You assume a fixed amount? Where does that come from? Where does that come from?

DR. LETELLIER: From steam generators and the core.

DR. WALLIS: That stuff that's already loose but does the, I'm just saying does the LOCA itself loosen some oxide from the fuel? It's probably overheating? There are some local heat-up, isn't there, in that?

DR. LETELLIER: So we haven't analyzed the fuel damage pathway in --

DR. WALLIS: Well, it's not necessarily damaged but it does overheat without damage.

DR. LETELLIER: We're using inventories that are consistent with assumptions for equipment qualification and containment, so the inventories of crud are present in other engineering calculations as well.

MEMBER BLEY: Now, that's not, just for Graham's point, that's not crud that's in mixture in the coolant. That's supposedly crud that's generated by the event.

DR. WALLIS: Generated by the event. That answers that then.

MEMBER BLEY: Because the water in there, normally you don't find hunks of stuff in it because it's pure.

DR. WALLIS: No, but the event may generate stuff.

MEMBER BLEY: That's the only place it could really come from.

DR. LETELLIER: Thank you. I missed that and, indeed, this is an additional particulate source that comes off of the fuel.

DR. WALLIS: And that is already considered.

DR. LETELLIER: Right.

DR. WALLIS: Yes.

MR. KEE: But with regard to the temperature, we don't analyze that in detail. When we do have a temperature excursion, yes.

DR. WALLIS: Yes, you do. You have a PCT that goes up.

MR. KEE: Yes, sir. Absolutely.

DR. WALLIS: So that does something to the crud on the fuel, doesn't it?

MR. KEE: Yes. Likely, and we attempt to take that into account by -- I don't know that we take the whole inventory though. We need to look into it. We'll have to get back to you on --

DR. WALLIS: Okay, thank you. All right.

MR. KEE: -- what we actually have assumed there but, yes. We're almost there. All right.

CHAIRMAN BANERJEE: I can see that you're homogenizing your pools.

MR. KEE: So, yes, so we've generated. We've found out how much of this various debris has been generated. We put it into the pool, and I might mention that we have a fraction of the debris that is initially put on the strainer as the water arises.

CHAIRMAN BANERJEE: I understand that you treat each pool as a perfectly stirred tank.

DR. LETELLIER: That assumption was addressed in RAIs and it's supported by CDF calculations of turbulence for a conservatively high fraction of fines.

CHAIRMAN BANERJEE: Fine. Yes, yes. So anything entering the pool instantly gets to the outlet in terms of its response function?

DR. LETELLIER: That's correct.

CHAIRMAN BANERJEE: And you get exponential decay, right?

DR. LETELLIER: That's right. And because of the numerical diffusion involved with that assumption, we artificially advance the material to the strainer sooner than it would in reality.

DR. WALLIS: Realistically doesn't it all settle out in the pool?

DR. LETELLIER: I would like to think so.

DR. WALLIS: Well, can't you calculate that?

CHAIRMAN BANERJEE: Well, it depends on the turbulence level.

DR. WALLIS: Is there any turbulence? It's 0.013 percent.

MR. KEE: Well, the thing that we have to keep in mind is that the water that's coming out of the -- Well, of course, we're pumping like mad water into the --

DR. WALLIS: And you're stirring it up by the way you put water into it, yes.

MR. KEE: It drops down. Yes, sir, in specific locations so --

DR. WALLIS: Yes, that's something you

could change that would make things much better.

CHAIRMAN BANERJEE: You could but, you know, we've seen some German experiments, I think you were there, where there's a lot of stirring.

DR. WALLIS: Well, waterfall will stir it up if you're pouring it in that way, yes.

DR. LETELLIER: There's the break flow and there's cascade returning through designed drain paths and stairwells. That's right.

CHAIRMAN BANERJEE: It would be hard to justify anything else. Okay. Let's go on.

MR. KEE: So then we already mentioned the fractionation of the flows. This is for a cold leg break. We said we've screened hot leg break. And we're basically keeping track of the debris at three places, the pool, on the strainers, each individually, and in the core.

CHAIRMAN BANERJEE: All you're doing is solving a set of mass concentration equations.

MR. KEE: That's correct and --

DR. LETELLIER: Bottom line and it's the primary reason we track things in terms of mass.

DR. WALLIS: But it's all mass. It doesn't say anything about the particle size distribution or anything like that.

CHAIRMAN BANERJEE: No. In fact, if you wanted to, of course, you could solve something like a Boltzmann equation with a probability density function and then just multiply it by the particle size distribution and you'd do exactly what Graham wants. It would simply be a mass conservation equation. Yes, it would. I assure you.

MEMBER CORRADINI: No, I'm not, I mean, we're not in neutron field today or aerosol field.

CHAIRMAN BANERJEE: No, but it's the same thing.

MR. KEE: So just an illustration. Someone asked about what do we do with all these things. We build up some stuff on the strainer. This debris comes --

CHAIRMAN BANERJEE: But just going back to --

MR. KEE: Oh, sorry.

CHAIRMAN BANERJEE: -- what Graham said, I mean, even if you wanted to do it within that framework you could propagate distribution of mass quite easily. You can, yes.

DR. LETELLIER: But can I just -- If you

know what the distribution is and --

CHAIRMAN BANERJEE: To start with and then you can follow it.

MEMBER CORRADINI: So can I just go back to these balance equations? So I guess when you follow these things, there's a character what's being tracked.

So just to be clear -- Maybe I just assumed that and I'm incorrect. If I track the mass, I know the character of the mass in terms of debris size, et cetera, on some sort of average basis. Is that true?

MR. KEE: Just fines and smalls transport, right?

DR. LETELLIER: Yes, we're assuming some --

MEMBER CORRADINI: Well, you've broken it down into bins. My question is if I've got 100 grams of this stuff going through, I know how much in the bin is fines and smalls?

DR. LETELLIER: Yes.

MR. KEE: Yes, we do know that.

DR. LETELLIER: It's predominantly --

DR. WALLIS: But the fines, you don't say that the fines are 2 millimeters long or a centimeter long or, you know, that makes all the difference in the world to what happens at the strainer.

DR. LETELLIER: We assume that they can always be homogeneously mixed.

DR. WALLIS: Makes all the difference.

CHAIRMAN BANERJEE: But I guess it's the, you can give this fine whatever characteristic you want to, right?

DR. LETELLIER: We can, I mean, as far as we're not attempting to take credit for settling or agglomeration or any of those physical processes.

MEMBER BLEY: Or take the penalty for the small stuff getting into the core.

DR. LETELLIER: No, indeed, we are assuming it does transport as small and --

DR. WALLIS: How small is small?

MR. KEE: To the core, right?

DR. LETELLIER: So let me, we haven't talked yet about our treatment of particulate. When this particulate arrives at the strainer, we assume 100 percent filtration from the point of view of NPSH.

We also use the 7-1/2-gram limit in the core which was a test condition that included both chemicals and particulates so, in essence, we're taking a double penalty for the presence of the particles.

MEMBER BLEY: So you assume it's all in the strainer?

DR. LETELLIER: And all in the core according to the test condition, to the extent of the test condition.

MR. KEE: And that is fines on the, they do grind that up in a grinder, in a mixer to get the core fines.

DR. WALLIS: This is what, the particles?

MR. KEE: By the time they have run through a, you know, the Cuisinart, they're pretty much very fine.

DR. WALLIS: But that makes all the difference in the world, how long you run the Cuisinart for and how sharp the blades are and what the speed is and this seems to be the most undefined experiment. You put in a Cuisinart and grind it up.

When I grind up my coffee for different times, I get different kinds of, sometimes it blocks the filter completely in the coffee maker so, I mean, it's very important how you define what you're doing in the Cuisinart.

CHAIRMAN BANERJEE: The question is do you characterize or do you look at the fibers or whatever they are after the grinding up of this stuff, chopping it up?

MR. KEE: We have actually -- Now I'm going to look at Rodolfo. We've characterized some of the particulate that bypasses on a small scale and I know that the Owners Group, for example, is looking at the same kind of information for fuel testing and so there is information being created and information that exists but that information will tell you that -- What's the distribution? Do you recall?

DR. VAGHETTO: Well, I recall that it ranges from particles that are very small. We have actually used a technique to measure particulate down to --

DR. WALLIS: The basic issue I have is how does what comes out of the Cuisinart with an undefined specification have anything to do with what happens in the LOCA?

CHAIRMAN BANERJEE: But, Graham, I think we -- I want to go back one step. What are you doing? You're chopping up the fiber. Are you adding fiber and particulate separately? Are you mixing them? What are you doing?

DR. LETELLIER: In a test configuration

the standard approach is to, and this is formulaic, chop the fiber into blocks and separate the fiber with the jet, high-pressure jet mixer to avoid mechanical fracturing of the fibers, the so-called NEI preparation method which I assume you're familiar with.

CHAIRMAN BANERJEE: So now you've got fiber and then you add particulate separately, which is what?

DR. LETELLIER: Depending on the test procedure, they could be actual epoxy acrylic coatings. They could be surrogate materials like in the case of latent debris, the dust and dirt. And according to evolving and accepted test procedures, they're either pre-mixed or they're added separately so that we can measure the --

CHAIRMAN BANERJEE: Yes, depending on what you're doing, right.

DR. LETELLIER: That's right.

MEMBER REMPE: So I know you're going to get into it more later, but at a high level could you talk about how you use these equations and how they interface with the RELAP/MELCOR computational approach? Is it just that --

DR. LETELLIER: No.

MEMBER REMPE: -- you're supplying boundary conditions to these?

DR. LETELLIER: No. These equations are completely driven by the flow rate, the queue of the pumps.

MEMBER CORRADINI: So to put it differently, there's no feedback to whatever happens in MELCOR and RELAP?

DR. LETELLIER: That's correct. These guys are carried along and there's no feedback to how it might affect the overall flow.

MEMBER CORRADINI: The only feedback is we have adjusted the flow for break size, right?

MALE PARTICIPANT: Sure, right.

MR. KEE: So the flow through the strainer is modified for the SI flow and then also we modified for different combinations of containment spray pumps. There's somewhat different flow rates.

DR. LETELLIER: So they're actually, every term in here is time dependent because we are sampling the operator action time to turn off sprays and --

MEMBER CORRADINI: We were just talking so I was wondering if there's a feedback. The answer's no.

MEMBER REMPE: But no temperature. Just

flow is the only thing though --

DR. LETELLIER: For mass transport that's correct. However, the temperature affects the NPSH of course, the delta P at the strainer, and temperature also affects chemistry we can talk about.

CHAIRMAN BANERJEE: So, okay.

MR. KEE: So just we calculate net positive suction head based on the accumulation of debris, the head loss through the strainer and the flow down to the pump and we also have mentioned that we calculate if voiding occurs.

And this is just the next slide. I keep forgetting to mention the slide number. Twenty-five shows that basically we evaluate the head loss for the different loadings given the flow rate through the strainer.

And, as Bruce just mentioned, if the temperature produced out of our thermal-hydraulic analysis drops below 140 degrees with a fiber bed that will accumulate particulate we add a chemical uncertainty factor and otherwise we don't --

DR. WALLIS: I don't understand why it was so low for 16-inch bed. You only add a factor of one for 16-inch bed, right?

MR. KEE: In effect we don't take any, we assume that -- Look at the equation, yes.

DR. WALLIS: Chemicals can't accumulate on a 16-inch bed?

MR. KEE: Well so 140 degrees, and I think Kerry can speak to this later, but in our observations is probably a pretty good temperature threshold for the appearance of precipitants should they appear.

DR. WALLIS: No, I'm just worried about the 16th-inch thing. You have a huge factor for a thick bed, you know, 24?

DR. LETELLIER: Let's examine the equation so I understand your question. First of all, if it's less than a 16th of an inch, then that factor is unity. There is no chemical.

DR. WALLIS: Why not?

DR. LETELLIER: It's assumed, even in the simplified method, that if you don't have a 16th-inch equivalent it's difficult to form a contiguous bed.

DR. WALLIS: It's assumed?

DR. LETELLIER: Well, it's also observed in practical testing.

DR. WALLIS: That true in Argonne tests, that there was no effect of a 16th-inch bed?

DR. LETELLIER: It's very challenging to form something less than a 16th-inch bed. The assumption on the table is that if it's not contiguous that it does not affect the --

DR. WALLIS: How thick is a 7.5-gram layer on the fuel assembly?

MEMBER CORRADINI: You're back to the question you asked at the beginning, strainer.

MR. KEE: Yes, the strainer, yes.

DR. WALLIS: Well, it's the same thing. They're both strainers.

MR. KEE: Oh, but on the core we don't do this assumption. So for the 7-1/2 grams it's not --

DR. WALLIS: Just trying to figure out why there's no chemical effect with a 16th-inch, what did I say, 16th inch.

DR. LETELLIER: We can answer that. We have UNM testing in a vertical loop --

DR. WALLIS: Okay, there's a backup test, okay.

DR. LETELLIER: Of course, 18 grams forms a bed that's several inches thick which is comparable to the dimension of a fuel assembly. So you're easily surpassing 16th of an inch with 7-1/2-gram in the fuel assembly.

DR. WALLIS: Okay. Seems odd looking at my strainer in my shower which blocks everything when you can hardly even see the bed.

CHAIRMAN BANERJEE: All right. Let's go on. And getting into --

MR. KEE: Again we, okay, sorry. So again we compare the margin. If we see the net positive, the loss down the strainer exceeds the margin, then we go to failure to the net positive suction head and we look at the, as I already mentioned, mechanical collapse, so if the pressure exceeds mechanical collapse value. If voids are created, greater than two percent, and that's at the strainer, we assume that we have cavitated the pump.

DR. WALLIS: I'm really puzzled by this because we had a meeting, I'm sorry, we had a meeting where there was a discussion about how many layers of fibers were on these very thin beds.

And it turned out that even for a very thin bed there was something like 60 layers of fibers because they're so small. They're 7 microns thickness. So we were talking about beds which were much less than a 16th of an inch. I don't understand. You're saying that it's like this. Something doesn't fit at all.

CHAIRMAN BANERJEE: Well, we can investigate this because -- So 15 grams of fiber in a fuel assembly, how thick does that come to, I mean, when it's compressed?

DR. LETELLIER: Well, it's substantial.

CHAIRMAN BANERJEE: It's substantially more than 16 --

DR. LETELLIER: Yes.

CHAIRMAN BANERJEE: -- a 16th of an inch? I've never sat down and done this.

DR. WALLIS: Why did we have this discussion in previous meetings with these very, very thin layers of --

CHAIRMAN BANERJEE: Yes, we need to go back and talk to the staff and --

DR. LETELLIER: We'd like to offer with respect to the equation we just looked at, the onset of chemical effect, that we've looked at sensitivity studies and that assumption is not, our risk is not particularly sensitive to that assumption. We could say that it applies at Time 0 and we have a few percent increase.

CHAIRMAN BANERJEE: I mean, you could have zero instead of 16th and it would make no difference?

DR. LETELLIER: We could and it would make just a modest increase. It's not a driving consideration.

CHAIRMAN BANERJEE: Well, I guess that would be interesting to know. Okay, because that gets rid of that whole discussion.

DR. LETELLIER: Incidentally these sensitivity studies are documented in a report from the University of Texas so it may not be considered 100 percent comprehensive and it is very thorough and it begins to explain many of your questions.

MR. KEE: Okay. So I think we started with a plant state and we've come to the point where we've found where we've exceeded thresholds if they are exceeded or if we don't exceed thresholds and that is for one path through, the kinds of things we do to get to these conditional failure probabilities and, of course, we do this many, many, many times in kind of a Monte Carlo setting.

CHAIRMAN BANERJEE: So I think what we'll do now is take a break and we'll reassemble in 15 minutes, which would be 10 to 11:00. We need to actually break at 12:00 because we have another meeting at lunch. So 12:00 to 1:00 I'll have to hold that break.

And what we want to do is to organize it so that we discuss the things which we can that John doesn't have to be there because he wants to be involved with all discussions in the PRA.

And so my suggestion is that we start with a very brief thing on the CASA Grande but he wants to be involved with that of course. Then we can go into whatever depth you want on thermal-hydraulics because I don't think John is particularly interested and that maybe is not the right word, interested.

MEMBER CORRADINI: His attention is elsewhere.

CHAIRMAN BANERJEE: Yes, and then we can start on chemical effects and we'll break quickly at 12:00.

MR. MURRAY: So what do we plan when we come back from the break? Do thermal-hydraulics, in-vessel effects and move through and then what we'll do is we'll be flexible. When John gets back, we'll find the right opportunity to talk about the interface with the PRA?

CHAIRMAN BANERJEE: So what we'll do is maybe take that up after lunch. And just if it doesn't encumber you too much we can start with the thermal-hydraulics.

MR. MURRAY: We should be able to accommodate that so we'll start thermal-hydraulics after the break?

CHAIRMAN BANERJEE: Yes. So we'll take a 15-minute break till 10 to 11:00.

(Whereupon the above-entitled matter went off the record at 10:36 a.m. and resumed at 10:53 a.m.)

CHAIRMAN BANERJEE: So we go back into session. And I hand it back to you, Mike.

MR. MURRAY: All right, thank you. We had the request to look at two slides. This will discuss some of the architecture of the building, layout of the building. The other slide will be the diagram of the, a picture actually of the sump strainer.

MR. KEE: So this is Ernie Kee again. On the left side as you face this picture, for ACRS and the audience on the left side, you see where the -- where's the cavity?

(Off the record comments)

MR. KEE: So the sump strainers are located down in this area. This is accumulators, so there's three trains, as we mentioned. You can't see the other train.

This is a four-loop Westinghouse pressurized water reactor that, of course, that's four steam generators. The steam lines go out the north part of the containment building and the refueling cavity's back to the south.

And the fuel handling building is where all this safety injection containment spray pumps and so forth are located. And these are fan coolers. There's six reactor compartment RCFC, reactor containment fan coolers, that actually, when we get a SI actuation. And they are independently cooled from service water. It's a component cooling water.

CHAIRMAN BANERJEE: What's that green thing there?

MR. KEE: And the green thing, this green thing, it's a big green thing. What is that green thing?

(Off the record comments)

CHAIRMAN BANERJEE: Okay. But it's of no importance to us right now.

MR. KEE: I don't know what that is. I really don't. And I mentioned that there's some blockage. So this one train is behind -- of strainers, these are all these enormous strainers are behind a wall. So that kind of tends to keep one of them from accumulating a lot of --

MEMBER BLEY: How far around the containment do the strainers go?

MR. KEE: This is the extent to the --

MEMBER BLEY: Two degrees?

MR. KEE: Yes.

MEMBER BLEY: That's the whole, that's all --

MR. KEE: Well, you don't see the, there's one more around the corner here.

MEMBER BLEY: That's what I thought.

MR. KEE: Yes.

MEMBER BLEY: But just one more.

MR. KEE: Yes. Just one more, yes.

MEMBER BLEY: Okay.

MR. KEE: So that's three.

MEMBER BLEY: So that's almost all of it there.

MR. KEE: Yes, sir. And this is the 19 foot, so there's holes, as you can see. And these are the ones we talk about that can fall down, where water can fall down. Now, in this case it's in the annulus.

And then there's a bioshield wall. And the bioshield wall has four holes in it that are roughly 18 inches off the mat. And they're three feet in diameter. And they're located here, roughly here, and here, and then out here and over there.

So the water has to come through the bioshield and come up over those, initially at least, up over those 18 inch curbs into those three foot holes. And all the water that's being recirculated out the reactor coolant system goes down into that interior area that's surrounded by concrete and comes back out to these strainers.

CHAIRMAN BANERJEE: Well, what are those, what looks like gratings on the floor? But I don't know what they are --

MR. KEE: So this here?

CHAIRMAN BANERJEE: Yes.

MR. KEE: There's a --

CHAIRMAN BANERJEE: That rectangular --

MR. KEE: That may be indicating the secondary sump. They're primary and secondary. So there's actually sumps that you can pump water out of containment that --

CHAIRMAN BANERJEE: Operation systems.

MR. KEE: Operationally --

CHAIRMAN BANERJEE: Normal collection.

MR. KEE: Yes, sir.

CHAIRMAN BANERJEE: Okay.

MR. KEE: So I think that's what's being shown there. There's two of those.

CHAIRMAN BANERJEE: So let's move to the next slide.

MR. KEE: Is there another one? Oh, am I in control?

CHAIRMAN BANERJEE: You said you had a slide of the strainers themselves.

(Off the record comments)

MR. KEE: So I mentioned that these are, we call them crenulated. So you these almost like disks with a central core tube right here. So they're stacked disks with these very small holes. You can almost see them here. It's like a screen almost.

MR. DR. LETELLIER: : The plates are, they have one inch gaps between them. And they're approximately one inch thick. And they're constructed of perforated stainless steel.

CHAIRMAN BANERJEE: Yes. So typically our question always with this type of strainer is, as you accumulate debris and you fill up the space in between, then your approach velocity becomes really the approach velocity on the face of that.

MR. KEE: Yes, sir.

CHAIRMAN BANERJEE: And that's the question I was asking.

MR. KEE: And we account for that.

CHAIRMAN BANERJEE: What is that? What is that approach velocity?

MR. KEE: Oh, oh, the --

CHAIRMAN BANERJEE: You see, because now you have a much smaller area.

DR. LETELLIER: I promise to provide that number specifically, but we do account for the transition to the circumscribed base area.

CHAIRMAN BANERJEE: Right.

DR. LETELLIER: And that's accounted for by tracking the accumulation of debris and using a geometric loading table that's specific to this design.

CHAIRMAN BANERJEE: Okay. So your approach velocity, of course when it's empty, is very low. It's what, 0.01.

MR. KEE: Yes, 0.01 feet per second.

CHAIRMAN BANERJEE: Feet per second or something. But of course, as it gets filled up it gets up.

MR. KEE: Yes. That's correct.

CHAIRMAN BANERJEE: Higher values.

DR. LETELLIER: And we calculate that as a function of time.

CHAIRMAN BANERJEE: But you've done testing with these interstitial spaces getting filled up with debris?

DR. LETELLIER: Typically, the test is on a single module. Maybe you could point out what a module looks like.

MR. KEE: Yes. So roughly, let's see, right here, between these tabs, you see these tabs.

CHAIRMAN BANERJEE: Yes.

MR. KEE: That's one module. And then they're ganged up and then --

CHAIRMAN BANERJEE: Right. But do you test one of those?

MR. KEE: Yes.

CHAIRMAN BANERJEE: Yes. And then you allow sufficient debris to accumulate so the spaces get filled up in between?

MR. KEE: Yes. That has been done.

DR. WALLIS: Does it fill up?

MR. KEE: Oh, absolutely. Yes.

CHAIRMAN BANERJEE: And it does. We have seen them, yes.

DR. WALLIS: It does fill up. And then you get a pile of debris on top of everything?

MR. KEE: Yes. It just makes a fluffy --

CHAIRMAN BANERJEE: And where is the testing done?

MR. KEE: Alden is where, I believe, all of our testing has been completed so far.

CHAIRMAN BANERJEE: And these strainers are supplied by whom?

MR. KEE: PCI, Performance --

CHAIRMAN BANERJEE: Yes, okay. We know them, right.

MR. KEE: And just mentioned that this is not part of the strainers. It's actually a fence that was put there. And someone asked early on the question about, well, what if somebody runs into these strainers and cuts it open or something.

And so we've put these strainer fences to prevent, in an outage, people running around with poles and so forth from busting through one of the strainers.

Okay. This thing's actually the level.

So you can see here how the level in the sump is monitored during an accident.

CHAIRMAN BANERJEE: River of water basically flows into this area, right? Because you've got a wall on one side and this is --

MR. KEE: It completely submerges these strainers.

CHAIRMAN BANERJEE: Yes, yes. The water just runs in here, but it doesn't run out anywhere? It just accumulates in this area.

MR. KEE: Initially, yes, it fills.

CHAIRMAN BANERJEE: It just fills it up and --

MR. KEE: And you can see here this plenum where it goes down, as Bruce mentioned earlier. I think he mentioned that there's a sump below there, a large cavity where it kind of accumulates and fills up. So as the water comes in, that is what we -- that fill term where there's this fiber that gets on the strainer. The start time is the volume of water that goes down into there.

CHAIRMAN BANERJEE: Okay. Thank you, that's very useful. Let's move on. That was very good.

MR. KEE: That's just one train. Okay. So what we have to --

(Off the record comments)

MR. KEE: Yes. So that's right. We're going to move to thermal hydraulics with Rodolfo.

CHAIRMAN BANERJEE: Just to ask you a question on this, you know, in the early days we used to see a lot of people doing CFD of the flows and things into these, the transient flows. Do you still do that sort of calculation? Or you just go with some more --

DR. LETELLIER: We've made use of those existing calculations that were done for the deterministic study at South Texas.

CHAIRMAN BANERJEE: Right.

DR. LETELLIER: And we used it to justify our assumption of homogeneous mixing and other assumptions about transport corrections.

CHAIRMAN BANERJEE: So when were those calculations done? I'm trying to remember. Was that about ten, 15 years ago or --

MR. KEE: Yes, several years ago.

CHAIRMAN BANERJEE: Yes.

MR. KEE: Not that long, but --

CHAIRMAN BANERJEE: I sort of remember it historically. So --

MR. KEE: We have that.

DR. LETELLIER: Fifteen years would have been the original CFD calculations at Los Alamos. So most of the plants have done --

DR. WALLIS: Ten years.

DR. LETELLIER: -- their own, yes, their own calcs since.

CHAIRMAN BANERJEE: Okay. And do you use, what, fluent? Or what did you use at that time?

DR. LETELLIER: FLOW-3D.

CHAIRMAN BANERJEE: Oh, FLOW-3D, the Los Alamos code.

DR. LETELLIER: Yes, that's correct.

CHAIRMAN BANERJEE: That's FLOW-3D.

DR. LETELLIER: Yes. The original Los Alamos calculations were done with FLOW-3D. Alliance Science did a number of calculation using FLOW-3D. I can't say that's the exclusive application.

CHAIRMAN BANERJEE: Okay. Thank you. Fine, let's move on to, we'll circle back to Casa Grande, the PRA one, after lunch. For an hour, roughly, a little less, right now.

MR. KEE: Thank you. Please go ahead.

DR. VAGHETTO: So my name is Rodolfo Vaghetto. I'm at Texas A&M University. And we have performed the simulations. We're using system code to analyze the system and containment responses during loss of coolant accidents.

The first slide is an introductory slide. It's to show out some of the thermal hydraulic calculation results have been implemented into Casa.

So I think some of you already mentioned, and I know that we have used the system code to perform the calculations. We have prepared the input model for the reactor containment using MELCOR and by using MELCOR to simulate the reactor containment response.

We have used RELAP5-3D to perform simulation of the reactor system. And we have created two different input models, one that basically uses only one dimensional component and is used to perform a long-term cooling calculations.

So we have performed the calculation where we have extended the calculation time over 30 days, over long-term cooling reactor, the sump switch over time. And then we have also the 3D model where we have used multi-dimensional components available in RELAP5. And this model has been used specifically to run some core blockage scenarios.

CHAIRMAN BANERJEE: So just remind me, in the core the code uses a two-fluid model or is it --

DR. VAGHETTO: Yes, yes. Basically a conservation equation are reached for --

CHAIRMAN BANERJEE: Then you don't have any drift flux part of it, right, in the vertical pipe?

DR. VAGHETTO: Well, if you're ever in the vertical pipe, say the core is modeled as a vertical component in that case, yes.

CHAIRMAN BANERJEE: Is there a drift flux or is it two-fluid --

DR. VAGHETTO: It's a two-fluid model.

CHAIRMAN BANERJEE: No. How do you get the levels all right with the two-fluid model?

DR. VAGHETTO: Okay. So usually when we run the simulation, we take into account of the collapse of liquid level. So what you do, you basically assume that all the liquid level is at the bottom of the core and the vapor is at the top. It's a parameter that we use to verify what is the amount of liquid available in the core on the average during the phases of the accident.

CHAIRMAN BANERJEE: So your core heat up, and core uncovery and long term cooling must be very sensitive level swells.

DR. VAGHETTO: Yes. I agree with you.

CHAIRMAN BANERJEE: If it's uncovered, it's going to heat up. And it's going to melt eventually.

DR. VAGHETTO: Yes. Well, I mean, like all the models that are available in RELAP5-3D for analysis of loss of coolant accidents are modeled. They are available also in the RELAP5, the U.S. NRC version of RELAP5 that is --

CHAIRMAN BANERJEE: Yes. But the things that we are concerned about is the use of two-fluid models to look at core uncovery, whatever they are, whether they be COBRA-TF, or RELAP or whatever. I think the jury is still out to know how well they can manage level swell.

So, you know, this is not a closed subject, using these codes for small break LOCA. Now, RELAP has been, of course, been used extensively. But that's why I was asking you how much confidence you have in the level swell calculations.

DR. VAGHETTO: Well, the level of confidence that we have, the one right before me, the loss of coolant accident, has been grown based on the extensive use of RELAP5 that has been done so far when analyzing the coolant.

CHAIRMAN BANERJEE: For small break LOCAs comparisons with LOBI and all these others. So at some point we need to revisit this a little bit to understand.

MEMBER CORRADINI: Can I ask you a question? So is the RELAP calculation tuned to a DBA calculation that already the licensee has? What I'm trying to figure out is there's so many parameter's in RELAP5 I wouldn't know where to start touching them.

But on the other hand, is it somehow tuned, so what I get in this calculation is equivalent to what is done in terms of licensing application? I'm not sure if South Texas does best estimate or Appendix K. But --

CHAIRMAN BANERJEE: Well a small break, there's no way you can do a best estimate currently. We haven't --

MEMBER CORRADINI: Okay. So then they do Appendix K?

CHAIRMAN BANERJEE: It has to be, yes.

MEMBER CORRADINI: So my question is, is it somehow tuned, so at least to get to your question, it may not be right but at least it's consistent. That's what I --

CHAIRMAN BANERJEE: My concern is for the back, to use thermal hydraulics in a best estimate sense when we have never proved, for small break LOCA, a best estimate calculation.

MEMBER CORRADINI: But I thought they're getting into trouble.

CHAIRMAN BANERJEE: Are they using it in a best estimate --

MEMBER CORRADINI: Right. But I thought they were getting into trouble. When they do get into trouble it's for a large break.

CHAIRMAN BANERJEE: Yes. But they are legislating a large break away using a risk-informed approach.

MEMBER CORRADINI: Okay. So your concern is that, because it's being used in a best estimate sense where there's very little data to --

CHAIRMAN BANERJEE: Small break.

MEMBER CORRADINI: Right. Where there's very little data to validate it, you're seeing things that may be unusual.

CHAIRMAN BANERJEE: We don't know. I have never seen a best estimate small break calculation that I would say is, you know, is acceptable at the moment. I mean, the staff can come into this if they wish. I think there are people at the staff who know this. But I've not, have you seen a best estimate small break LOCA calculation?

MR. SMITH: I'm not the right person to talk about those.

CHAIRMAN BANERJEE: Well, Paul is here. He doesn't want to speak?

(Off the record comments)

CHAIRMAN BANERJEE: But I think that this is still an open subject. We are looking at full spectrum LOCAs, right? And there is no clarity. Okay, Len Ward can speak. I'm asking the question if you are using RELAP in a best estimate sense for a small break LOCA, you know, what validation is there for that at the moment?

MR. WARD: Well, I'm not using it in the best estimate LOCA --

(Simultaneous speaking)

MR. WARD: I use it in Appendix K.

CHAIRMAN BANERJEE: No, Appendix K we have no problem.

MEMBER CORRADINI: First identify yourself.

MR. WARD: Yes, Len Ward, NRR.

MEMBER CORRADINI: You look awful relaxed.

MR. WARD: I just got back from vacation.

CHAIRMAN BANERJEE: But here I understand that this is somewhat like a best estimate calculation. Or is it not? Is it an appendix scale or best estimate?

DR. VAGHETTO: We try to be close to best estimate, in other words, we try to reproduce as much as possible close to the real plant conditions, if that answers your question.

CHAIRMAN BANERJEE: Yes. So what evidence do we have that RELAP5 can be used at the moment in a best estimate sense? Is there a validation database for that?

MR. WARD: I guess I can use the example of Appendix K methodologies when vendors do their benchmarking, Appendix K, they'll try to predict the data. I mean, they're not using all these conservative assumptions.

And so they'll put in their best, if it's drift flux they'll put in their best correlations for a level swell. They'll put in the correlations for critical flow, all that important parameter CCFL, to try to predict the data.

I guess you asked about data. There's semi-scale. So 710(d) is a small break LOCA that uncovers with a loop seal effect. There is the ROSA test. But there's not a lot of uncovery there. But there's loop seal phenomena. There are --

CHAIRMAN BANERJEE: What about LOBI?

MR. WARD: There's LOBI, there's some small break tests there.

CHAIRMAN BANERJEE: PKL?

MR. WARD: There's PKL. I'd have to say that the database for small break LOCA integral tests that uncover is pretty limited. But there are a number there that one could and should use to benchmark a code to show that, in an integral sense, they can match integral data. And those tests would be appropriate for that.

CHAIRMAN BANERJEE: But to your knowledge, has RELAP5 been used and validated since, because you know more about RELAP5 than most people, in this context? What is the validation that --

MR. WARD: It has. Those tests have been run.

CHAIRMAN BANERJEE: They have been?

MR. WARD: Years ago, but they have been done.

CHAIRMAN BANERJEE: With a two-fluid model?

MR. WARD: Probably the drift flux model was --

(Simultaneous speaking)

MR. WARD: Where they would extract the drag from the, the relationships from the drift flux, yes, two-fluid drift flux.

CHAIRMAN BANERJEE: So that correlation's backed out of the data?

MR. WARD: That data that, the interfacial drag is extracted from the drift flux formulations for a bubbly slug, annular, whatever implosion it happened to be. But it's, you know, like I said though, there's limited benchmarking.

CHAIRMAN BANERJEE: Okay.

MR. WARD: I mean, it's not extensive.

CHAIRMAN BANERJEE: I think we will need to look into use of these in a best estimate sense for a small break in more depth. But thanks, Len.

MEMBER CORRADINI: But just, can I

summarize what Len said so I can understand? So there are selected, there are a limited set of data?

CHAIRMAN BANERJEE: Yes. We'd have to look into what database there is. But I'm sure the staff will too when they do their SE runs.

MEMBER CORRADINI: Maybe we should ask the staff when they come up, they are coming up?

CHAIRMAN BANERJEE: Well, they will eventually have an SE.

MEMBER CORRADINI: Well then, okay.

CHAIRMAN BANERJEE: At the time of your SE, I guess, this would be an issue we'd be interested to know more about, also in the 3D sense. Okay. Go ahead.

DR. VAGHETTO: We have coupled the RELAP5-3D in MELCOR. So we are able to simulate the containment response and the reactor system response during loss of coolant accident scenario.

MEMBER CORRADINI: Just to circle that, so I do use this in a different application. But my guess is there's a team at Idaho that've actually rerun these compared benchmarks.

So I think staff ought to know when they release a new version of RELAP5 what are the three dozen or one dozen tests, comparisons they make every time they do an error correction or a re-release, et cetera. So we should be able to get that so you feel more comfortable.

CHAIRMAN BANERJEE: Yes. I think when the SE comes in front of us, clearly we will be satisfied by --

MEMBER CORRADINI: But I only wanted to make sure that my memory is I'm almost sure that they do that.

MEMBER REMPE: I'm pretty sure they do that too.

DR. VAGHETTO: Yes. And to comment to your question is like all the latest version of RELAP5-3D release that has all the user manuals online, and one of the user manuals is basically all the comparison of all the previous tests available with all the RELAP5-3D simulations. So --

(Simultaneous speaking)

DR. VAGHETTO: -- code assessment of --

MEMBER REMPE: It's been electronically too.

CHAIRMAN BANERJEE: So the difficulty, as you understand, as Professor Wallis invented with Novak Zuber the drift flux model, is using a two-fluid model for level swell as the fundamental problem. So it goes beyond what you're doing here. Basically you're using something which has got to back out the drag correlations from a drift flux model.

DR. LETELLIER: If I might clarify, your primary concern is with regard to peak temperature estimation, correct?

CHAIRMAN BANERJEE: Well, uncovery, you know. And so when you do these calculations, what is the flow you need in order to maintain cooling in the core, right? And that calculation is very delicate using codes like this.

DR. LETELLIER: I understand it's sensitive and perhaps complex, but is there an appeal to a conservative assumption where a complete collapse perhaps may expose the fuel for our purpose of a threshold of concern?

CHAIRMAN BANERJEE: Well, if you take a bounding approach of some sort that the core is completely covered and there's no uncovery then it doesn't matter. But, you know, then you don't have to use RELAP5. You can do it with a hand calculation.

DR. LETELLIER: Right. Thank you. The thermal hydraulics results are being used in several different ways. And I perceive that your primary focus is on the temperature in the fuel.

We're also using it for the temperature of the containment pool, and also for system response for total injection flow as a function of break size and the temperatures in the containment for chemical effects.

CHAIRMAN BANERJEE: Yes, that's fine. But when you get to the core I assume you're using RELAP5-3D to argue that --

DR. LETELLIER: Yes.

CHAIRMAN BANERJEE: -- you're getting acceptable cooling even when the core is blocked and all that sort of -- I read all those words. Those are very iffy, I would say, right now. Maybe if it doesn't help your case, you don't want to go into a three year process trying to justify that.

DR. WALLIS: Can I raise another issue, Sanjoy?

CHAIRMAN BANERJEE: Huh?

DR. WALLIS: Can I raise another issue with this?

CHAIRMAN BANERJEE: Yes.

DR. WALLIS: And that's the loop seal clearing issue.

CHAIRMAN BANERJEE: Which is even worse. Yes, of course.

DR. WALLIS: Because if your loop seal doesn't clear, you've got that thick hydraulic head to fight against or only water for the core.

(Off the record comments)

CHAIRMAN BANERJEE: Because, you know, these codes have never been used in a best estimate sense. So once you're going down that path, you are trying to justify use of these codes, the best estimate codes. And then you get all the problems Graham is talking about.

How do you show that the loop seal was clear, it was not reformed, core level depression? Do you really want to go there? I would worry. And I'm sure the staff will be worried. It's very different using it as best estimate which is what you're trying to do.

DR. LETELLIER: So let’s go on to how we have used it.

DR. VAGHETTO: Yes. Well, I mean, one of the reasons why we wanted to use RELAP5-3D is it sounds probably as new code, but in reality it's been developed from the RELAP5 U.S. NRC version. So it has all the models that U.S. NRC RELAP5, there have been --

CHAIRMAN BANERJEE: Don't get me wrong. I mean, we have been following all this. Our concern is that none of these codes have been considered as best estimate codes for small break LOCAs or long term cooling.

I mean, it's different if you do an Appendix K calculation. We accept that. Is this plant a small break LOCA limited or large break LOCA limited for peak clad temperature?

MR. KEE: I don't know the answer to that. We can find out.

CHAIRMAN BANERJEE: Okay. Because some of the Westinghouse plants are small break LOCA limited, some are large break LOCA.

DR. LETELLIER: So one of the findings of our study so far has been that small breaks do not generate enough debris to challenge the safety systems. So it's predicated on the filtration efficiency, of course, but under the assumptions of thermal hydraulics Rodolfo's assuming complete blockage for his assessment. So there is a conservatism built in to the progression of the accident scenario. If perhaps we can consider when --

CHAIRMAN BANERJEE: But you, basically, when you start to block things the phenomena that we are concerned about is things like level swell, right? So when you start to block and you starve the core coolant or whatever, then all the things that we worry about for small breaks -- and this is an open subject that's probably going to be taken care of over the next three or four years when we build a full spectrum LOCA, you know, probabilistic method -- those issues arise here if you try to do it this way.

You know, the other way is, of course, to do what the staff says, 15 grams per assembly. That's fine. Because that's based on testing, right?

DR. LETELLIER: I would love to raise the limit to 15 grams.

CHAIRMAN BANERJEE: Anyway, let's go back to this. You understand our concerns with this, right?

DR. VAGHETTO: Yes. Just talking maybe a little bit more about small breaks and remembering what was the outcome of some of the simulations when we assumed the full core blockage at the bottom of the core, the small break code like was one of the cases that we said went to success.

In other words, even if you assume a full core and core bypass blockage, at the sump switchover and for a small break the sump switchover is basically several like the order of 10,000 seconds after the break opening because of the small flow.

So what happens is that we see that there is a large amount of water coming from the surface injection system in the core from this alternative flow path. And we have seen that the core is basically flooded.

So in other words, it's like a spool of leak. And I was just thinking of what you say, that when the core is full of leak with maybe the problem of not having the drift flux model can be somehow overcome.

CHAIRMAN BANERJEE: But you also then have to take account of what Graham was saying, which is that if you reform the loop seal you can get core level depression. So you have to check that, what's happening.

DR. VAGHETTO: I can also check so see what is the level, what is the liquid level of both the core to see like an overpressuring in the vessel can basically --

CHAIRMAN BANERJEE: Because hot leg injection will not get rid of that problem. So you might want to talk to them about it.

DR. VAGHETTO: Yes.

CHAIRMAN BANERJEE: How do you use RELAP-3D? What's the point of doing that?

DR. VAGHETTO: Well --

CHAIRMAN BANERJEE: If the core is full, what do you care?

DR. VAGHETTO: Well, we can actually, we could have done some type of the simulation that we have performed with the NRC version of RELAP5. The reason why we wanted to use the RELAP5-3D is because in addition to what we can do, let's say, in this slide with the 1D, one dimensional component, we can also model certain region of the vessel, including specifically in the core with the multi-dimensional components, a more detailed representation of the core that otherwise will be basically with the vertical pipes.

CHAIRMAN BANERJEE: But what is the basis of this? I mean, this has never been approved or validated has it?

DR. VAGHETTO: Well, we wanted like, the simulation we have performed with the RELAP5-3D were just to answer questions regarding what could that bring to the core instead of, let's say, assuming a full core and core bypass flow but if we maybe leave open a fuel assembly in the specific location of the core. And it's something that we were able to do only if you have 193 fuel assemblies simulated in the core. So you can --

CHAIRMAN BANERJEE: So this was just a study for interest?

DR. VAGHETTO: It's a study of interest to see whether, like cases that were assumed to be fail with a one dimensional component, maybe with different other features of the model may show a different behavior that we couldn't analyze with the one dimensional model.

MR. KEE: So we were curious about, for example, for the hot leg break condition, what about how much of the flow is circulating around in the core, what does that look like? And with the 1D model, you can't see anything.

CHAIRMAN BANERJEE: So this was qualitative. You're not going to put any -- because we have grave suspicions about the veracity and validity of these codes in this type of situation. And it'll be a few years before this is settled.

Because, I mean, there are submissions in front of us to go to full spectrum, use of codes for full spectrum LOCA. But we haven't, it's a long way before we settle that issue.

MR. KEE: Yes. So we've explained our failure criteria. And we're not relying on, in particular, the 3D model as direct support for that result.

We do think that it gives us indication of what kind of safety margin you may, say, may be available in this rather, I call it an extreme assumption of blockage and so forth. So it helps understand what the level of --

CHAIRMAN BANERJEE: But do you use these results in any part of your analysis other than getting qualitative information?

MR. KEE: We refer to them qualitatively in our submittal as an indication of safety margin. It's asked for in Reg Guide 1.174, so for example, these blockage scenarios where we leave just one fuel assembly open, for example.

CHAIRMAN BANERJEE: And I understand what you're doing. The question is how reliable are those calculations?

MR. KEE: Given that consideration, we are removing hot leg breaks from consideration of concern based on thermal hydraulic analysis. So you want to look carefully at that.

CHAIRMAN BANERJEE: Yes. Because of the recirculation patterns?

MR. KEE: No, no.

DR. VAGHETTO: In that case it was more because of, we have seen using this model and in this slide so it's basically 1D model, we have seen that for hot leg breaks, since we started at the sump switchover, that all the SI pumps, they're injecting the cold leg break. The only way for the flow to go through the core is through upper plenum sprays and after through the steam generators.

So the simulators show that there are alternatives to a part, even if you assume a full core and core bypass blockage for hot leg break based on the relative position of the injection and the break.

CHAIRMAN BANERJEE: So what you're saying is that, unlike the PWR owners group where the core blockage for the hot leg break is the limiting core blockage, correct, you don't find that the limiting core blockage?

MR. KEE: In terms of blockage, it is limiting. In terms of success it's not.

CHAIRMAN BANERJEE: Okay.

MEMBER CORRADINI: Say that again, again please?

MR. KEE: Sure. So the most fiber will accumulate on the core in a hot leg break scenario. We showed that picture where it has fractionated by what goes around and what -- but in the hot leg there's no opportunity for that fractionation to take place. It all has to go through the core. So it's the same reason why the water from the injection comes back around to the core.

CHAIRMAN BANERJEE: So we'll have to look at that very carefully. Because that is what limits the in-vessel blockage, that's where the 15 grams comes from, is the hot leg.

DR. WALLIS: It did not have to drive it through the core.

MR. KEE: It turns out we don't, actually. Because, what, by our simulation we don't. We have it totally blocked off. Both the core and the core bypass are blocked off.

DR. WALLIS: So how is then cooled, comes in from the top?

MR. KEE: Correct, yes.

DR. VAGHETTO: So there are upper plenum sprays that basically come in --

DR. WALLIS: Plenum sprays.

DR. VAGHETTO: -- first, and then you can also have, depending on the break size, you can have -- they also flow through the steam generators.

MEMBER CORRADINI: So this plant has upper plenum injection.

DR. VAGHETTO: The upper thermal sprays that mentioned are basically their flow, a small flow path that basically, due to communication, the top of the downcomer, I'm selecting this junction that they're presented the upper plenum sprays.

CHAIRMAN BANERJEE: Oh, it comes from the downcomer --

DR. VAGHETTO: From the top of the downcomer to the upper plenum.

CHAIRMAN BANERJEE: The little holes there.

DR. VAGHETTO: Yes. At steady state, there is a small fraction that is used from the cold side to cool down that B

(Simultaneous speaking)

DR. WALLIS: -- has vent valves or

something up there, has check valves up there.

MR. KEE: That's actually holes, holes.

DR. WALLIS: Do you just have holes?

MR. KEE: Permanent holes to cool the head. It's one application for those holes.

MEMBER CORRADINI: Oh, so this is just a normal leak path that keeps the top of the head cool?

CHAIRMAN BANERJEE: Correct.

MEMBER CORRADINI: Oh.

CHAIRMAN BANERJEE: How big are those holes?

MR. KEE: Yes, I knew that was coming. I don't know the exact size of it. But we can get that.

DR. WALLIS: Will they get blocked by debris? Can they get blocked by debris?

MR. KEE: It's not likely. But we recently changed the size of those too, not recently, but to get to cooler head we've made those larger. But we have to look it up. I don't know what the size is. So we'll look up the size of the holes.

MEMBER CORRADINI: But just so I understand the logic, so the logic, when I asked you to repeat, your point is that I get some sort of small percentage of flow that comes up through those holes but then leaks back down into the core.

MR. KEE: Yes, sir.

MEMBER CORRADINI: Perfect.

CHAIRMAN BANERJEE: That's why you need the RELAP-3D calculations to show that you can get cooling from that small flow.

DR. WALLIS: And in the cold leg break, it doesn't get high enough to go in that way?

DR. VAGHETTO: The answer is yes. And it depends on the break size. So, I mean, it's larger breaks, the pumps, they cannot have the driving head to reach that elevation. But the smaller break, what I mentioned that the break, actually we simulated a two inch break. That's what we have seen.

CHAIRMAN BANERJEE: This becomes an important flow path.

MEMBER SCHULTZ: Yes. I think the statement that wasn't validated by you was the conclusion that you're drawing conclusions from the RELAP5-1D model. Are those verified, have those been verified by the RELAP5-3D model, those conclusions of cooling?

DR. VAGHETTO: We didn't run all the same scenarios. I mean, a small, medium and large in hot

LOCA and cold leg breaks. So we have run basically six simulations. And then out of those simulations, since I would show you in the next slide, since the RELAP5-3D is a large number of nodes, the simulation time is very large.

So we add the two selected, the ones that were more interesting from our standpoint. So we didn't run any small breaks, for example. But we selected the cases, for example, the cold and hot leg break. In cold leg, which were found to be fail. And then we selected that six inch break and we used a 3D model. And we started changing the assumption is the core blockage.

So instead of having the full core blockage, what happens if we leave the bypass open? Is the driving head able to force the flow through the core bypass in reaching the top of the core? Or if we leave one fuel assembly open, is the flow through that only one fuel assembly, is it enough to remove the decay from the core?

MEMBER SCHULTZ: So if we go back to this, is it the holes that cool down --

CHAIRMAN BANERJEE: Possibly what we should do, we've only got 25 minutes, is have Rodolfo run through the results. And we can always revisit this later. But let's get through what you have to say before lunch.

DR. WALLIS: Sanjoy, it seems these holes to the upper plenum must have their mechanism for getting rid of, you know, three-quarters of the problem. And yet we don't know any details about them.

CHAIRMAN BANERJEE: We will find out.

MR. KEE: Of course, they're modeled in detail. We just don't know off the top of our head what those --

DR. WALLIS: Are you going to show us that this afternoon or something?

MEMBER CORRADINI: Dr. Wallis wants to ask him a question, right?

DR. WALLIS: Well, I mean, this is one of the key things that you do, is to use those holes and you haven't told us anything about them.

CHAIRMAN BANERJEE: And we'll come back to that. So let Rodolfo finish. And then we'll make a list of questions which we want answered or more information on. So go ahead.

DR. VAGHETTO: So in general, for both 1D and 3D model, we have given some specific feature of the plant. So we have four independent loops. We have three independent surface injection chain in each one with the high and low pressure injection pumps and accumulator.

The reason why we have given these features is because, later on I will show you, we have run simulations where we assume a different plant state and pump state. So we wanted to be able to talk now of the pumps at the beginning of each transient to run that specific plant scenario.

We have also implemented some manual operations. So we have done our automatic and manual operations. And we mentioned, for example, that sump switchover time. So when we reach the low, low level alarming the RWST which to the surface injection to the long term cooling and then, at a certain point in time approximately six hours from the break event, there is a manual operation to switch two of the three trains to hot leg with circulation.

This is the slide that basically represents how we started from the 1D model and selected certain regions of the core and basically used a multi-dimensional component.

And regarding specifically the core, we

have modeled the core using 193 fuel assemblies, each one as a heat structure so we can give realistic radial and also axial power distribution to the core.

The big figure on the right is basically a top view of the core nodalization. So we have given the shape of the back of the --

CHAIRMAN BANERJEE: So your downcomer is 1D, right?

DR. VAGHETTO: The downcomer is also 3D. The green component, the 521, has been converted to --

CHAIRMAN BANERJEE: But not 3D in a real sense?

DR. VAGHETTO: It's a 2D, it's a 2D, because we didn't use, we used only one node in the radial direction.

CHAIRMAN BANERJEE: The radial variation?

DR. VAGHETTO: Yes. It's a 2D component.

CHAIRMAN BANERJEE: These are complexities which we shouldn't gloss over. Because, in fact, it's not 3D.

DR. VAGHETTO: Yes. Yes, but the core is a real 3D component, because he has all the three, X, and Y and Z dimensions.

CHAIRMAN BANERJEE: It would only be 3D if you resolve the fuel rods, which you didn't do.

DR. VAGHETTO: Okay. Yes, well, in that sense I agree with you.

CHAIRMAN BANERJEE: Yes, going, overstatements should be carefully --

MEMBER CORRADINI: It's a homogenized 3D.

CHAIRMAN BANERJEE: It's homogenized. It's vaguely 3D.

DR. VAGHETTO: Again, the core in this case has over 2,000 nodes to represent just the core. So --

CHAIRMAN BANERJEE: We do calculations with billions of nodes so --

DR. VAGHETTO: Yes.

CHAIRMAN BANERJEE: It's not particularly impressive.

DR. VAGHETTO: Yes, I know. Like in terms of number of nodes, maybe may not say anything. But we were able to run simulations for several hours. So that's unaltered.

And this is the nodalization adopted for the reactor containment in MELCOR. So we have six nodes, six compartments. And again, just like RELAP5-3D, we have also implemented specific plant operations. So we are able to secure one of the three containment sprays at the beginning as part of the manual operation procedure. We can turn off all the three sprays after a certain time whenever the pressure goes below a certain limit. We have six independent fan coolings.

DR. WALLIS: I want to ask you something basic here. You have a model which has steam and water separate. What about the debris? I mean, if you boil something with debris in it, the steam comes out and the debris stays behind in the water. And you would do that in the core?

DR. VAGHETTO: Neither RELAP5-3D nor --

DR. WALLIS: Do you follow the debris?

MEMBER CORRADINI: I think we -- I don't mean to, but I think that's what were asking earlier, is that this just provides flow and temperature conditions, and their mass flow and all their split fractions in that set of conservation equations is where all that determination is.

DR. WALLIS: I know. But what I'm saying, does the steam carry debris or just the water?

MR. KEE: Well, at time of that initial explosion that we hypothesized, then debris is blown everywhere.

DR. WALLIS: Oh, in the long term cooling.

DR. LETELLIER: Right. It follows the proportion of flow. And it --

CHAIRMAN BANERJEE: Just the water, right?

DR. LETELLIER: -- there's no transport with the steam.

CHAIRMAN BANERJEE: It just stays with the water.

DR. LETELLIER: That's right.

DR. WALLIS: So if you ever dried out at the top, you'd just build up debris in the core. As it comes in, it wouldn't have anywhere to go, right?

DR. LETELLIER: That's right. So for the cold leg break, the proportion of flow is driven by the boil off, assumption of boil off. And for the hot leg break, it's driven by the --

DR. WALLIS: But if you've got the boil off, and you're recirculating debris it would presumably just fill up the core.

DR. LETELLIER: We assume that it's 100 percent collected at the inlet so that we can judge against our minimum threshold. So we don't take any credit for homogenization of the debris. It's completely --

DR. WALLIS: All I'm saying is if the debris gets into the core, and you're boiling off, it'll stay there.

DR. LETELLIER: That's right.

DR. WALLIS: And if it keeps coming in, it'll get more of it, right?

DR. LETELLIER: That's right.

DR. WALLIS: Do you do anything about that?

DR. LETELLIER: The scenario would fail as soon as we exceed seven and a half grams per fuel assembly, statistically speaking, it would fail.

DR. WALLIS: Because you, okay, assume that --

(Simultaneous speaking)

DR. LETELLIER: And we're not concerned about core damage or severe accident space. Once we've exceeded the threshold, then that scenario is terminated in essence.

DR. WALLIS: So the debris going into the core doesn't matter, seven and a half grams per assembly is, if it does it doesn't matter, right?

CHAIRMAN BANERJEE: So I do want to finish this by 12:00. So let's --

MEMBER REMPE: But before we go on, I have a question about coupling.

CHAIRMAN BANERJEE: Very last question.

MEMBER REMPE: Okay.

CHAIRMAN BANERJEE: Just for you.

MEMBER REMPE: Thank you. Coupling between MELCOR and RELAP. I even looked at your backup slides. And so I can see some of the parameters, not all of the parameters that you selected to couple.

But timing, how did you select the timing for the coupling to know you've done it appropriately and you're not losing mass, or energy or anything? And did you do sensitivities? Do you always have the same timing or some sort of criteria for it? What was your approach?

DR. VAGHETTO: So we started with the a definite approach for the coupling. The coupling that we started with was basically manual coupling where we actually ran a simulation with RELAP5.

We instructed the parameter of the break, like mass and energy, gave it to MELCOR, then ran another simulation in MELCOR to flood the parameter, like pressure to give like to the break discharge and sample temperature, and give it back to MELCOR and go back and forth until the solution basically converged.

In other words, between a step and a step plus one you have difference in the parameter that you want to analyze that was below a certain limit that we said after this iteration we can accept the final simulation.

Now we have implemented a routine. But remember, we don't have access to the codes. So what the routine does, run a simulation of, let's say at the moment, a certain delta T for RELAP5. Then it takes the integral value of the break at the end of that delta T and gives it MELCOR. And MELCOR then runs an alternate delta T and so on.

Now, we did perform a sensitivity analysis on that delta T, because that is a delta T of our restart. So we performed the similar restart. And at the end of restart we basically exchanged the information between RELAP5 and MELCOR. And the parameter that you see in the backup slides are basically the ones that we select.

We have done sensitivity, and we have compared a simulation used with this automatic routine to the one that we have used with the manual operation. And we basically tuned our conflict in a way that we were confident that the results could reproduce the one with the manual coupling.

MEMBER REMPE: Thank you.

CHAIRMAN BANERJEE: Okay. All right, keep going.

DR. VAGHETTO: So this set of slides basically shows the type of simulation we have performed with RELAP5 and MELCOR. And these slides, the next one, 47 and 48, gives an idea of the amount of the simulation we have performed to study the containment response.

So in this case, RELAP5 is used as sooth to the containment. And we have run simulation, as I say, that's for a long term period, it's a long term cooling period over 30 days after the sump switchover.

And we have analyzed the different break sizes, different pump state, different engineering safety features state and different plant operation conditions, in particular the CCW temperature which is used to cool down the secondary side of the RHRE exchanger and the final cooler thing, the STP.

We have assumed three different temperatures to simulate a nominal assignment on our winter scenario, that's the way we called. And the table on Slide 48 shows basically 28 scenarios that we have simulated with RELAP5.

CHAIRMAN BANERJEE: a question, how dependent is this on nodalization? Because if you --

I assume that in this time scale each node is just simply very well mixed, right? So whatever signal it is is transmitting, depending on the number of nodes, that would be the speed. It is sensitive, the results?

DR. VAGHETTO: Well, we have done sensitivity not only on the nodalization but also on the DT stack of each of the two codes. And we tried to give it with respect with that given nodalization in a way that it was as less sensitive as possible.

Then after the sump switchover, what we have seen with this large scenario, the time derivative are very small. So that sensitivity is easy when less important later in the transients.

CHAIRMAN BANERJEE: But there are some transport steps here, right? You're transporting fluid, or transporting temperature or transporting whatever, right? So in a sense, by assuming everything is well mixed, the pools, that gives you a series of sort of stirred tanks to go through.

But I'm wondering, is there any transport aspect that you have to capture here to get an accurate rendering of what's going on? Or does it not matter? Is it all just well mixed?

DR. VAGHETTO: Again, especially like if

you look at the nodalization of the containment which are of very large nodes, I'm not expecting that the transport term in between nodes in the containment in that phase would, I mean, of course I stated flow between nodes. I'm not sure whether sensitivity, again, in the nodalization that we have performed or in the deepest level will change the results in that term.

DR. LETELLIER: If you look at the case definitions on the far right, you'll see that some of the boundary conditions, some of the inputs, have to do with ultimate heat sink temperature. And the degree of variation in some off the boundary conditions may overwhelm the resolution.

CHAIRMAN BANERJEE: Right.

DR. LETELLIER: So there's a choice to be made.

DR. VAGHETTO: Yes. Even if some of this temperature we tried to be, let's say, close to the real value. But for some other, let's say what we call the winter, we have assumed a CCW temperature of 150 Fahrenheit which is not realistic for our temperature of the CCW. So we have bounding cases to where probably part of the containment response is within this variability.

CHAIRMAN BANERJEE: So what you are really telling me is that nodalization, and time step and these things won't really matter.

DR. VAGHETTO: It does. And we did a sensitivity. And for family of simulations we had to adjust the time step of the coupling to make sure that the simulation was converged in each phase of the accident. So we had to --

CHAIRMAN BANERJEE: So you did test for convergence as you went along, you test for convergence with nodalization?

DR. VAGHETTO: Correct. The nodalization testing that we have done at the very beginning for the DT step is mandatory, I mean, is required when you use system codes, that when you change a parameter like break size or plant state that you want to make sure that --

CHAIRMAN BANERJEE: When you did the nodalization convergence study, what did you find that it was --

DR. VAGHETTO: Well, actually nodalization that we have used for both RELAP 5 and MELCOR, are nodalizations that are very typical for BWR, Westinghouse, four loop. So we started the formal nodalization that was already used in many other publications and literature.

And also we have used the sensitivity in both the RELAP5-3D and the MELCOR model that gives suggestion to the user to start with a typical nodalization. So the nodalization sensitivity didn't actually show any major effect.

We have done, for example, one of the last sensitivities in nodalization of the steam generator, and we came to the conclusion that the number of nodes in the steam generator U-tubes were not affecting the simulation based on the parts of this simulation.

CHAIRMAN BANERJEE: Okay. Eventually, you tell us why you think the leakage through those holes keeps the core cool, right? That's really the bottom line that we're interested in.

DR. VAGHETTO: Yes. I have two drives, but one in the summary table is more or less in this slide presentation is what we have just mentioned. So this is example of parameter that we have instructed from all the simulations. This is parameter that we have provided to different other teams.

So we have clocked, then provided the sump switchover time as a function of the break size and plant conditions, total inside flow rate and the sample temperature provided.

And this is the second set of simulations that we started talking at the beginning. And it's about like this core blockage scenarios. So the first set is basically, it was performed using the one dimensional core model.

So we have a core with the two pipes, one representing the average channel and one representing the hot channel. And we have assumed that full core and core bypass blockage at the bottom of the core. So we have artificially blocked the junctions that simulated the flow path from the lower core plate to the core.

And we have run six simulations. So a simulation representing a small break, a two inch break, a medium break, a six inch, and a double-end guillotine break. And these three simulations will be repeated in cold and hot leg, so in total, six simulations.

The conclusion that we came out with this 1D model -- and I can, maybe if you give me the opportunity so I can talk with table -- is something summarizing this table here. And it's something that we already partially discussed.

So when you have a -- the sump switchover time, the three injecting loops, basically injecting the cold leg, so the break location is very important. Because if the break is in the cold leg the flow is diverted around the vessel. And it basically is directed directly to the broken leg.

But everything now depends on the break size. If the size of the break is not small, then the pump head can basically force the flow and then basically fill the downcomer that was most empty at that time and force the flow through the upper plenum spray. The upper plenum spray, they have --

CHAIRMAN BANERJEE: Is this a spray or is it just going over --

DR. VAGHETTO: They are taking it, we call the upper plenum sprays, but they are a series of holes all the way around the vessel at the top of the downcomer which, in the 1D model, was simulated with the one junction which has the total flow area of the holes and the hydraulic diameter of one.

And of course there is a pressure drop there that we have fine tuned a steady state to make sure all the plant conditions --

CHAIRMAN BANERJEE: So the reasons all these pass is that flow that goes through these holes into the top of the --

DR. VAGHETTO: Not only. At the beginning, you start having the flow through the upper plenum spray. But you may also have a flow through the steam generators. So the flow from the pump can be forced --

CHAIRMAN BANERJEE: Back up.

DR. VAGHETTO: -- back up through the steam generator U-tubes and then reach the core through the hot leg side. So there are two alternative flow patterns that we have identified with this simulation.

There is a third alternative flow path that we did not account in this simulation. And this flow path are called the pressure relief holes, sometimes called the LOCA holes. These basically are a different level of holes in the core baffle. So the water from the core bypass can actually enter into the core and not, like a different elevation in the core.

MEMBER CORRADINI: And you neglected those why?

DR. VAGHETTO: I'm sorry?

MEMBER CORRADINI: Why did you neglect them?

DR. VAGHETTO: At the very beginning, we had one main reason to simulate these LOCA holes. And you have to have the drawings. So at the beginning, basically, the drawings were not available. So what we did, we said, okay, we don't account for LOCA holes. And we tried to see, wow, like the --

CHAIRMAN BANERJEE: Oh, these LOCA holes?

DR. VAGHETTO: I'm sorry?

CHAIRMAN BANERJEE: These are the LOCA holes?

DR. VAGHETTO: Well, we don't have the right dimensions for SEP. They are approximately between one and a half and two inch in diameter each. And there are several holes in different elevation in the core. So there are relatively large holes. And again, in a scenario where you, for example, you assume the core blockage, but you assume a free bypass, and again, the --

CHAIRMAN BANERJEE: So when you do these calculations and the water comes in, you assume that the debris comes in with the water. They don't block the holes, but they just go through, right?

DR. VAGHETTO: So --

CHAIRMAN BANERJEE: I mean, two inch holes, they won't block. It'll just pass through into the core.

DR. VAGHETTO: Let me clarify first of all. I mean, the system code we used, we don't physically simulate the debris in any kind in the liquid face. So it's a pure liquid.

Now, when we block the core, we assume that the flow is zero at the bottom of the core. Then this altered flow reaching the core from altered flow path, we may run other simulation assuming that maybe some of these flow paths are also blocked. But we didn't take any assumption of debris transporting and possibly accumulating in these additional or alternative flow paths.

CHAIRMAN BANERJEE: Oh, in the fuel itself.

DR. VAGHETTO: Or in the fuel itself, yes.

CHAIRMAN BANERJEE: Okay. So bypass, you mean that it stays below what temperature?

DR. VAGHETTO: Well --

CHAIRMAN BANERJEE: Under it or --

DR. VAGHETTO: Okay. So 8800 was a limit that we have used it to identify cases that are assumed to be pass and cases assumed to be fail. And you can imagine a fail case, a medium or large break when you block the core, there is no way that the water can reach the top of the core. So if you plot the peak cladding temperature, it steadily increased until you reach the 800 Fahrenheit.

CHAIRMAN BANERJEE: The reason the cold leg failed was you didn't get the level up to --

DR. VAGHETTO: You didn't get --

CHAIRMAN BANERJEE: -- leaking out from the top.

DR. VAGHETTO: Correct.

CHAIRMAN BANERJEE: And the reason the two inch worked is that you simply got the level up and pushed water through the holes at the top of your downcomer.

DR. VAGHETTO: Correct. Because the break is small enough that you can --

(Simultaneous speaking)

MEMBER CORRADINI: And he said it one way. I want to make sure. You pushed it both directions. I thought your explanation is you pushed it this way, and you also pushed it through the core.

DR. VAGHETTO: Well, the core is blocked.

MEMBER CORRADINI: A complete blockage, excuse me. I'm sorry.

DR. VAGHETTO: The core is blocked.

MEMBER CORRADINI: I'm sorry.

DR. VAGHETTO: So at that point you cannot have flow.

MEMBER CORRADINI: Excuse me.

(Simultaneous speaking)

DR. VAGHETTO: Well, the LOCA holes are not modeled, but they will become effective only if you assume that the core bypass is unblocked.

MEMBER CORRADINI: That's correct.

DR. VAGHETTO: Otherwise, you cannot have those LOCA holes to be --

MEMBER CORRADINI: So there's only one of these alternatives which would, they would actually be affected is when the bypass is unblocked.

DR. VAGHETTO: Correct.

MEMBER CORRADINI: Okay.

DR. VAGHETTO: Correct. So if I go back to this simulation which was performed with the multi-dimensional component model, so we select a six inch cold leg break, the one that we have found to be fail in the one dimensional component.

And we started to, let's say, decrease the level of being extremely blocking the core at the bottom of the core. For instance, the core bypass has a flow path at the bottom that is very large, in fact, two inch wide of the baffle to the core plate.

And it's all the way around the baffle. So it gets a very large flow area. So we wanted to run a simulation where we said, okay, we blocked the core, but we think we can leave the bypass open. And in that case, the flow through the bypass may be able to reach the top of the core.

CHAIRMAN BANERJEE: Of course, the flow has to distribute in this, it's all at the sides, right?

DR. VAGHETTO: All the way around the baffle. So basically you --

CHAIRMAN BANERJEE: Yes. So you then have to use RELAP-3D to get it to the middle, right?

DR. VAGHETTO: We have done both simulations with the 1D. We actually, we always start with 1D, because it's a simpler approach. And you can validate the model easier. And then we switch to RELAP5-3D.

But even with the 1D, you have to imagine now, 1D junction connecting the node of the bypass with the node that the same elevation of your 1D core. And you simulate the flow in that one node that will simulate your core average.

CHAIRMAN BANERJEE: Okay. So this is with your 3D, right now, what you're showing, right?

DR. VAGHETTO: Yes. So the 3D again, so --

CHAIRMAN BANERJEE: And this you looked to see how the water penetrates into the central regions of the core, of this core?

DR. VAGHETTO: What we have done, for example, the cases circled that we identify Number 3 and 4, we have assumed the full core blockage. But we have assumed that the sump switchover that one, only one out of 193 fuel assemblies remained open. We wanted to see if the flow through only one fuel assembly would be enough to supply the cooling --

DR. WALLIS: In your submission, you say that's quite likely. But it seems to me that if the other ones are blocked, the flow all goes to that one which would then become blocked. Because that's where the debris is also going. So maybe there's a way of evening things out in the core.

CHAIRMAN BANERJEE: But this is just a parametric study, you know.

MR. KEE: It's apparent. And maybe we should talk -- so the South Texas project the fuel, it has feet that stick down maybe about this high and then comes almost like a filter. It looks like that. Because all the guide tubes have to connect into a plate. So there's feet, four feet that stick down.

So there's this clearance under this core that's quite large. So this debris collects on that tie plate, if you will, the bottom tie plate of the core.

And then the core baffle walls, the former walls that make that look kind of cylindrical, but since they're square it can't be perfectly cylindrical, those walls come down. But then they come short by about two inches all the way around the bottom of the core.

CHAIRMAN BANERJEE: I think it would be helpful, maybe after lunch, to show us a picture of that if you have one.

MR. KEE: I don't know if we --

CHAIRMAN BANERJEE: Or you can show it later.

MR. KEE: To stay away from proprietary, we probably can't show you the fuel.

CHAIRMAN BANERJEE: Well, we can always close the meeting.

MR. KEE: Oh, okay.

CHAIRMAN BANERJEE: That's no problem.

MR. KEE: Maybe we can pull that up.

(Off the record comments)

CHAIRMAN BANERJEE: It would be helpful, because we want to understand the geometry of the problem. You know, the devil here is going to be in the details as to what reaches where.

MR. KEE: Yes. We did make a very simple schematic later when we talked, but, yes.

CHAIRMAN BANERJEE: I'd like to finish this, because people had to leave. We've lost three members right now. And I don't want to go on too much longer.

DR. VAGHETTO: Actually, that was the last, this was the last slide of the set.

CHAIRMAN BANERJEE: That's great. So I think, rather than take too many questions with an incomplete subcommittee, we've lost three members, because there's another meeting. I'd like to call a break now and reconvene at, say, five past 1:00. And then if there is anymore to be discussed with the thermal hydraulics, we can come back to it and then just proceed, okay.

MR. MURRAY: And we will find the one question which was the size and number of the holes.

CHAIRMAN BANERJEE: Yes.

MR. MURRAY: So that we can, we'll find that during the break.

CHAIRMAN BANERJEE: Whatever information you want to present after lunch would be very helpful. Okay. So we take a break now until five past 1:00.

(Whereupon, the above-entitled matter went of the record at 12:04 p.m. and resumed at 1:04 p.m.)

CHAIRMAN BANERJEE: So we're going back in session. With that, I think we need to maybe finish up the thermal hydraulic session, and you had a few other things to show us. I mean, essentially all the slides are done.

So if anybody had any questions, we could address those, but if you wanted to show us a couple of things, Mike, before we move on to CASA Grande.

MR. MURRAY: Well, we wanted to feed back specifically on the number of holes and size.

CHAIRMAN BANERJEE: Okay.

MR. MURRAY: And I think that was only open items there. And the drawing isn't that proprietary, but we'll discuss it in general terms to give you an understanding.

CHAIRMAN BANERJEE: We can always, at some point, close the meeting.

MEMBER STETKAR: The problem is if you put the drawing up, we are in an open session, it is then not proprietary.

MR. MURRAY: And we don't intend to put the drawing up.

CHAIRMAN BANERJEE: Why don't we hold it to some point where we can just close the session and deal with everything together that's proprietary. You might need some more details.

MR. MURRAY: Okay, so let's do it that way.

CHAIRMAN BANERJEE: Let's do it that way because we might actually want to see what it looks like.

MR. MURRAY: Okay, all right.

CHAIRMAN BANERJEE: So about the holes, is there something you wanted to say?

MR. MURRAY: Not much except that what we basically asserted is more or less true.

CHAIRMAN BANERJEE: So you can talk about the holes at the top, their size, or is that proprietary, too?

(Simultaneous speaking)

MR. KEE: No, that's the problem.

MR. MURRAY: That is what we're

discussing.

CHAIRMAN BANERJEE: The area and the hole size.

MR. MURRAY: That's correct.

CHAIRMAN BANERJEE: Let's do that, and then there was the inlet section you wanted to talk about as well at the bottom.

MR. MURRAY: Okay, I can get that. Those will be --

CHAIRMAN BANERJEE: Why don't we do this. I'll close the meeting towards the end at some point, and then we'll accumulate everything which is proprietary and discuss it then.

MR. MURRAY: That will work for us.

CHAIRMAN BANERJEE: Will that work? All right. So now let's move on with the CASA Grande, shall we, if we have no further questions on the hydraulics. John is back.

We do need to finish by maybe 5:45 today, so I'll try to keep it going. I have extended it. Listen, I'm not going to do --

(Simultaneous speaking)

MEMBER CORRADINI: Nobody accused you of being a dictator.

CHAIRMAN BANERJEE: Yes. Certainly not. Dana Powers will keep it until 9 o'clock. So that's that.

MR. MURRAY: We're available until 9 o'clock.

(Off record comments)

CHAIRMAN BANERJEE: All right.

MR. MURRAY: So we'll go through the PRA, then we'll move back in-vessel LOCA, and start going back through the agenda.

CHAIRMAN BANERJEE: So we are going to talk about CASA Grande interface now.

DR. JOHNSON: All right, let me start. My name is David Johnson.

CHAIRMAN BANERJEE: Let's orient the slide number.

DR. JOHNSON: I'm going to start on 29.

CHAIRMAN BANERJEE: Okay.

DR. JOHNSON: All right. And this is kind of a broad overview of how the PRA and CASA Grande are linked together. I also wanted to talk about changes we needed to make to the model of record so that it would address the GSI 191 issues, and if there's interest, to talk about how the GSI 191 model or the model of record complies with REV 2 of the REG guide 1.200.

So the role simply is to provide a mechanism for pulling all the bits and pieces together to be able to look at one aspect of REG guide 1.174 in terms of measuring the results or judging the results, and particularly looking at CDF LERF from delta CDF delta LERF.

We also were keenly interested in determining the characteristics of uncertainty in these metrics. And as you will see when we get into the example problems later, probably about 8:30 tonight, that uncertainty is something kind of embedded in each of the bits and pieces of the puzzle moving forward.

And that uncertainty is characterized and passed over to the PRA and propagated along with the non-GSI 191 uncertainty parameters that are imbedded in the PRA.

So it's important to understand that we're using 1.174 to provide this framework for judging the acceptability, or at least, you know, with the comparison to a hypothetical plant. And this is a perfect plant. This is one without any latent debris, without any GSI 191 issues at all.

So that doesn't exist, but we think that maximizes the deltas here, and is a decent measure of going forward.

MEMBER STETKAR: Dave, when is it appropriate to talk about uncertainty at sort of a fairly high level?

DR. JOHNSON: I'm going to show you --

MEMBER STETKAR: Are you going to wait until we're done, or do you have anything?

DR. JOHNSON: I'm going to show you something at the end of this short talk.

MEMBER STETKAR: Okay, okay.

DR. JOHNSON: I think, Bruce, correct me if I'm wrong, you've got a --

MR. LETELLIER: You were talking about the LOCA size frequency and break selection?

MEMBER STETKAR: I'm talking, you know, I didn't say anything specific intentionally. I said at a fairly high level.

DR. JOHNSON: We want to kind of talk about it where it makes sense, but it all is rolled together.

MEMBER STETKAR: All right, I'll wait.

DR. JOHNSON: Uncertainty is not something we did at the end of the day. It's imbedded in each of the analyses and passed forward to the next step.

Okay, one interesting thing, I think, is to talk about the changes to the model of record. And I think you'll be seeing similar slides like this when other people come to talk to you. There's key differences in success criteria.

You know, in the typical PRA, we ask do I have at least one of three pumps, or one of four pumps. Here, we wouldn't need to know exactly how many pumps we have because we need to characterize the approach velocity and the switch over times and things like that to a little more detail.

We use the different LOCA frequency model, which will --

MEMBER STETKAR: Before you do that, somewhere in this discussion are you going to talk about the venting algorithm that you used to come up with your five cases that were evaluated in CASA Grande and --

DR. JOHNSON: I can talk about it. I don't have a slide on that, but we can certainly talk about how we came up with those.

MEMBER STETKAR: Because as I understand it, CASA Grande ran five distinct cases in terms of numbers of pumps running.

DR. JOHNSON: Times three for small,

medium, large. But that's true. Okay.

MEMBER STETKAR: But just numbers of pumps running. And in somewhere, and I don't know where and how, there are 64 possible configurations among sprays, low head injection, high head injection that could exist.

And you argued that well, we took five of those were distinct, I can identify them. There were 11 more that you shoved into the five which left 48 others for which you assumed the sump always plugged because they were "unanalyzed".

DR. JOHNSON: Indeed.

MEMBER STETKAR: And when I look at the binning of the eleven into the five, it's not at all clear to me why particular combinations were binned to particular, you know, cases, I don't remember, 1, 9, 22, 26, 43 for example, for example.

DR. JOHNSON: Right.

MEMBER STETKAR: Do you have any quick insights on that?

DR. JOHNSON: I'm going to toss it to Bruce here in a second. But the argument is that the 11 if you will are bounded by the 5 that were --

MEMBER STETKAR: Yes, okay.

DR. JOHNSON: And that was done and documented in Volume 3, not Volume 2 if you're looking for it.

MEMBER STETKAR: They are, sort of.

DR. JOHNSON: And the cases that we ran across in the PRA that if they weren't explicitly analyzed or weren't bounded, we took those to core damage directly.

MEMBER STETKAR: Let me ask, and I don't, forgive me if you're going to go through this later. But if I look at Case 22, okay, which is the one train is out of service. So I have two of each of the high head, low head, and pumps running.

You have things binned into there that include things like three low head and three spray pumps running. Now that's more flow than two low head and two spray pumps. But it could be going to three screens. So it wasn't clear to me why the larger flow cases are bounded by the smaller flow cases.

DR. JOHNSON: Let me take a shot at that.

MEMBER STETKAR: They smelled more like pump case one, for example.

DR. JOHNSON: Good point. Remember we, at least in the current calculation, were turning off one train of spray early. Okay, step one. Two is, and I'll get Bruce to correct me on this --

MR. LETELLIER: Got it.

MEMBER CORRADINI: He made a note, so I think you got him.

MEMBER STETKAR: No, no, no. But I brought that up this morning is that that might be very optimistic.

DR. JOHNSON: No, John, let me --

MEMBER STETKAR: You know, and if that's the basis for the way they grouped it --

DR. JOHNSON: John, let me circle around and answer that one --

MEMBER STETKAR: -- it's curious.

DR. JOHNSON: -- again for you. But let's answer this question first is I think, and Bruce can correct me, is that the algorithm if you will was that if one sump plugs or has a problem, they all fail. Right?

MR. LETELLIER: That's always true. If any single pump or any single strainer fails, then that entire scenario fails. We don't have any accommodation for partial performance at all.

DR. JOHNSON: Let's circle back --

MEMBER STETKAR: Let me bring up a specific, I would like to get to specific examples. Pump state one includes one case, pump state one is nominally all the stuff --

DR. JOHNSON: Available.

MEMBER STETKAR: And it also includes a case where you have three high head injection, three low head injection, and two sprays. In other words, one spray not available. Okay, I got that, and I can sort of think about numbers of trains and number of pumps.

Pump state 22 has two high head injection, three low head, and three spray. This sounds to me like more flow with the same number of strainers as pump state one. I don't know why is that bounded by the model for two, two, and two?

This is my questions about why things were, but it affects frequency and it affects risk.

MR. LETELLIER: It does, it does. So we're not prepared to go through each of those --

MEMBER STETKAR: Okay.

MR. LETELLIER: -- assignments. But I will tell you that by assumption, it was assumed that pumps failing in the same train is worse than the same pump failing across different trains. Got that?

MEMBER STETKAR: No, because --

MR. LETELLIER: Pumps failing in the same train, alpha, bravo, charlie, is worse than the same purpose pumps failing across multiple trains. And the logic was this, it was related to debris accumulation at the strainer.

MEMBER STETKAR: Sure.

MR. LETELLIER: You're thinking about the potential for failing on an NPSH margin.

MEMBER STETKAR: Bruce, I understand that. I'll bring back the specific example that I cited. In pump state one, which is nominally modeled in CASA Grande as everything running flat out, you have binned into that a configuration with three high head injection running, three low head injection running, and only two spray pumps running.

Now, I understand that. I understand why that is appropriate. However, down in the pump state 22, which is nominally two, two, and two, in other words, one full train, Train A is out, let's say.

You have in that state two high head safety injection pumps running, three spray, and three low head pumps running. I don't get it. You were just telling me about assuming that all pumps in one train out is worse than one, you know, scattered individual pumps.

I can handle that, but I don't know why the two, three, three case is in 22 rather than number one.

MR. LETELLIER: Have you considered the flow rate on each of the high head and the low head pumps? So we're looking at totals.

MEMBER STETKAR: High head is pretty low compared to the spray and the low head pumps.

MR. LETELLIER: Right.

MEMBER STETKAR: So you know, I thought about that. I wasn't too awfully interested in numbers of high head pumps that were up and down.

MR. LETELLIER: We were also concerned about the validity of the logic. So we did our due diligence and we dug considerably deeper into this list.

And we found that in some cases, the logic is not airtight, partly because of the penetration that we talked about this morning, that in fact, a lesser amount of fiber on a low flow strainer can actually admit more debris to pass through.

And so we dug deeper into the matrix and we found some minor increases in risk that we could share with you in a study that we actually did.

MEMBER STETKAR: Well, minor increases,

remember I'm talking about PRA now. I don't know anything about fibers, I don't know anything about strainers, I don't know anything about the analyses you guys did. I'm just looking at combinations of pumps up and down which have frequency associated with them getting binned together into cases that you are then modeling from a plugging standpoint.

And if you shift some of these binning configurations around, you will change the frequency of those pump states, which you were then modeling, you know, the way you guys modeled.

And my question was I couldn't understand the rationale for the binning logic that was used. And I'm still not understanding, anything you're saying I'm still not understanding that. So I don't want to, we're going to be really pressed for time. And if it's a long answer, we'll just leave it and you can get back to us on it.

MR. LETELLIER: I think it's relatively short.

MEMBER STETKAR: Okay.

MR. LETELLIER: Let me try one more time. So CASA Grande is interested in simulating the performance conditions that could lead to failure. The

PRA must match the aggregate probability of occurrence into the proper branches of the PRA.

So after the selection is completed by whatever criteria, then the probabilities are aggregated so that they properly match.

MEMBER STETKAR: No, because rules are written, it says I use this probability for this combination of things in the PRA. If those combinations are not specified correctly, I'm assigning the wrong probability to the wrong combination.

And the rules, the thing that I'm looking at here determine the combinations for which those probabilities are assigned. So I'm still not understanding what you're telling me. I don't know if there's a simple answer.

DR. JOHNSON: I don't think there is a quick answer.

MEMBER STETKAR: You may want to go back and look at it.

DR. JOHNSON: Yes, we will.

MEMBER STETKAR: I looked back in Volume 3, I looked at the tables. But there too, there was not -- I looked at those tables and thought I saw what you were doing in those tables. But those tables didn't have all of the combinations that I was looking at.

I looked at the documentation for the PRA model to find out where the 11 things -- I understood the other 48, okay, that's easy. I understood the five that you could identify. I was curious about where the other 11 were getting allocated, and that's where I came up with this kind of logic.

MEMBER CORRADINI: So you're looking for a justification of how the 11 got placed?

MEMBER STETKAR: Exactly.

MR. LETELLIER: And your concern will persist, generically speaking, regardless of how deep we go in the table. We need to connect the dots and have a methodology that properly --

MEMBER STETKAR: Well, you know, if you only analyze five and only five cases out of the total 64, and assign the other 59 to death, we wouldn't be having this discussion. I'm only concerned about the rationale, you know, why you selected 11 rather than 18 versus, you know 9, that's a different issue.

But given the fact that you selected 11, why were they binned into the logic?

MR. LETELLIER: I think we can satisfy your concern. First of all, it's no longer a practical limitation. We can go deeper into the table, and we do have screening criteria based on frequency that we may choose to assign the rest to failure without implication.

MEMBER STETKAR: That's one way to handle it. But I see the PRA people perhaps --

MR. LETELLIER: Cringing.

MEMBER STETKAR: Let's just, in the interest of time --

MEMBER BLEY: Well, before you leave, the only thing I'd say, since you did this, it's surprising it isn't clearly explained just how you did it and why.

MEMBER STETKAR: I mean, you can look at the PRA model if you know how to read the stuff and see what was done. I can look at tables in Volume 3 that give me sort of a general philosophy about how different combinations might behave differently.

But that still doesn't tell me why precisely what was done was done in a logical sense. And maybe it all does make sense. I just don't get it.

MR. KEE: Well, so when we first attacked the problem, we were spending a lot of computer time, and we felt like we needed to reduce the scope of analysis. And since we've done this, we've found out wow, you know, like 25 percent, even that screening criteria 1E-9 frequency for the states that we relegate to failure are, like, 25 percent of our total failure.

So we can now, we've now analyzed a lot more states and will, as Bruce already commented, we are looking at --

(Simultaneous speaking)

MEMBER STETKAR: You know, people always do that simplification. You know, you can try to brute force it and let the lights dim. But given the fact that people do use conservative condensation or whatever terminology you want to use in terms of simplifying the models, I think the question that I'm asking is given the fact that you went that process, which a lot of people do, what's the rationale for the specific selections you're using.

DR. JOHNSON: It's a good comment that the rationale needs to be more fully --

MR. LETELLIER: And I believe the work's already finished now that we do have a deeper analysis of those combinations. It should be easy to satisfy.

MEMBER STETKAR: Okay.

DR. JOHNSON: And we'll be looking at more combinations explicitly going forward.

MEMBER STETKAR: The only reason I brought it up is your first bullet up there. I don't see any other.

DR. JOHNSON: Got past the first bullet then.

MEMBER STETKAR: You can get to the second.

DR. JOHNSON: Yes.

MEMBER STETKAR: You can even skip over the dash now.

DR. JOHNSON: But to circle back to your second comment which made this warning also is that we recognize that assuming the operator takes the action early on and later on, we recognize that as something we need to address, and we talked to staff about it.

It was an RAI, and we simply didn't have any CASA runs to match up there at all.

MEMBER STETKAR: Yes, I didn't have enough time to read all the RAIs and responses.

DR. JOHNSON: There were only 150 ones associated with the PRA.

MEMBER STETKAR: Yes, I didn't. Light reading. I got through 147.

DR. JOHNSON: Again, going back to difference with the model of record, different LOCA frequency model was used, I think that's obvious, new scenarios were added. You know, we took success branches in the event tree and, you know, added branches that looked at the sump and boron and vessel blockage, et cetera.

And as is obvious, the model of record, as is common, used some sort of generic sump blockage likelihood. That's been around for quite a while. And we've kept that in the model to the time being. It doesn't show up, but we're obviously doing a GSI specific, model specific evaluation of those types of scenarios.

I'd like to talk a little bit about how we address the failures after 24 hours. In principal, these phenomenon could occur over about a 30 day window, yet we're flanging it on to the model that has the typical 24 hour mission time associated with it.

And just a note that since we knew that the effects could be very, very small, it was necessary to use a much lower quantification truncation number. So we're pretty sure we didn't throw anything away in the bath water.

Next couple slides are not an eye chart. They just want to give me a chance to indicate that it became obvious that we could use a combined medium LOCA, large LOCA model to represent the plant response to medium or large LOCA.

We needed to add the high head pumps into the large LOCA model. They don't do anything to prevent core damage, but they do something to influence the approach velocity. So it was just easier to create a model, and again this isn't an eye chart. I'm just trying to point out to create a model that addressed both the medium and large LOCA scenarios.

And again, not an eye chart, but I just wanted to show the sequence diagram type of mode where the elements were that were added to the model for, I can't even read it, sump blockage. One of these is end vessel and one of these is boron. So they're appended to a nominally success state, if you will, which is important later on here.

You've seen this chart before, and I think you'll see it at least one more time today, the relationship between CASA Grande and the PRA. And you know, CASA Grande provides the input, if you will, for several specific elements associated with failure of the sump or failure in the vessel or by flow blockage and failure by boron precipitation.

And as John keenly pointed out, there is 15 of these flip factions if you will after the PRA, small, medium, large, and for the five pump states that we're evaluating.

I'd also like to point out that once we get into CASA Grande, and I think we'll see this during the examples is you'll see that it provides a very valuable tool to articulate what these scenarios are and some characteristics of the scenarios, the timing, the phenomenon that's going on, et cetera.

And conversely, it will let you to dig into the model to see where the welds, which are surrogate locations, which welds, which locations are contributing and why. So it's a good way to unravel things, also.

I think we've gone over this interface with CASA Grande is there is a discreet number of pump configurations. CASA Grande analyzes those, passes those as conditional failure probability distributions, including the uncertainty that represent the phenomenon of interest.

MR. LETELLIER: I'd like to clarify just to make sure the Committee understands that what we're providing to RISKMAN is a conditional failure probability, conditioned on the plant state and interrogated by formal uncertainty propagation measures. We have both an estimate and an uncertainty that we give to the --

MEMBER STETKAR: Characterized as a five bin discreet probability distribution, right, from what I read.

MEMBER BLEY: No. That was just what you gave us.

DR. JOHNSON: I think you might be reading an older version of the report.

MR. LETELLIER: Yes, please make sure you have Rev 2 of Volume 3.

DR. JOHNSON: That occurred to me this morning when you're talking about --

(Simultaneous speaking)

MEMBER STETKAR: Is that right?

DR. JOHNSON: -- documentation. There's a Rev 2 that was last November.

MEMBER BLEY: It doesn't say, actually.

MEMBER STETKAR: Yes. It is notable that the stuff we had had neither revision numbers nor dates on it.

MEMBER BLEY: No, it does have a date.

It's Rev 2.

MEMBER STETKAR: Rev 2? Okay.

MEMBER BLEY: That's the headline, right?

MR. LETELLIER: Yes. So the figure that you may be remembering simply doesn't have the resolution to see the additional --

MEMBER STETKAR: No, no. I was reading words. I didn't look at figures. They said there are five discreet probability values for each parameter that's passed to the PRA model. And of course, that's not true for FLBK because that's always either zero or one.

So now for boron and for sump, which are the only two things that are characterized by uncertainty, the only thing that I could read were five bin histograms.

DR. JOHNSON: Is that in Volume 2 or 3?

MEMBER STETKAR: You know, I can't remember.

MR. FONG: This is CJ Fong with the PRA branch. I think what you're looking at is actually an error that the staff identified as well, that Volume 2 talks about five discreet points, which is what the old rev of the submittal contained. We believe the licensee has now gone to a 15 point discreet --

(Simultaneous speaking)

MEMBER STETKAR: Okay, I read 15 for the LOCA frequencies. We'll get into more uncertainty later. And I understand the 15 for the LOCA frequencies. But I was only reading, and that was consistent. Everything that I read said 15 for LOCA frequencies.

DR. JOHNSON: Right. The staff identified that. And I think it was an RAI.

MR. FONG: Right, it was an RAI because when you look at Volume 3 for the conditional failure probabilities, Volume 3 says 15 points, Volume 2 says --

MEMBER STETKAR: Well, I was confused because originally when I read the two things, I thought that somehow there was an attempt to capture the uncertainty in, for example, sump plugging by, you know, the argument that that's bounded by the uncertainty in the LOCA frequencies, and therefore we're using that.

But after I sort of sorted through that, that was sort of a word understanding problem. The next thing I came up is that, well there's 15 bins, points, for the LOCA frequencies which seem to be documented clearly, but only five for the sump and the boron, which you're telling me is not the case.

MR. LETELLIER: It's a misstatement.

MEMBER STETKAR: Okay.

DR. JOHNSON: Yes, that was an earlier version.

MEMBER BLEY: So they're all --

MEMBER STETKAR: Fifteen bin?

MEMBER BLEY: -- PDPs, 15 bin PDPs?

DR. JOHNSON: Right.

MR. LETELLIER: Yes.

MR. KEE: We do try to propagate that uncertainty into the PRA. It comes through the --

(Simultaneous speaking)

MEMBER STETKAR: Well I mean, the question originally, even with 15 bins is small but it's better than 5, capturing those tales is really difficult in 15 bins.

MR. KEE: Yes, sure. And we've done optimization strategies --

MEMBER STETKAR: Or I'm sorry, five.

MR. KEE: -- on how best to choose those percentiles of the initiating event frequency. We've looked at various --

MEMBER STETKAR: We'll talk about initiating event frequencies later. But I don't want to mix, I want to be clear here.

MR. KEE: Sure.

MEMBER STETKAR: We have uncertainty in the LOCA frequency, right, that comes from slicing the LOCA exceedance frequency clears. We also have uncertainty in the conditional failure probability for top events sump and top events boron, right? That comes out of CASA Grande.

MR. LETELLIER: Correct.

MEMBER STETKAR: CASA Grande doesn't care about the uncertainty and the LOCA initiating event frequency for the sump plugging, does it?

MR. LETELLIER: Yes, it does. In fact --

MEMBER STETKAR: It does. Well, that's what I want to understand how all of these uncertainties are combined and where.

MR. LETELLIER: So maybe we could clarify right now. I'm not sure what your opinion will be. But it's important to understand that CASA takes all of the uncertainties in parameter values, and they're completely integrated into a best estimate value. We have --

MEMBER STETKAR: Okay, first of all I don't -- okay that's good, thanks, because I certainly didn't know what that meant.

MR. LETELLIER: So recall that we're implementing a statistical design, and experimental design for sampling the values of specific values in the parameter distributions. And we're running many thousands if not a few million scenarios to look at the outcomes.

And we run those in batches so that we can prove that we have adequate sampling to some residual sampling error that's acceptable. But at the end of the day, we have a best estimate for each of the percentiles from the initiating event frequency.

So we have not preserved the variability from any single parameter value because they've been integrated out in this statistical design.

MEMBER CORRADINI: Can you repeat that last part? I'm sorry, I'm as cloudy as they are, but I'm just listening. So say that last part one more time, please.

MR. LETELLIER: We have not explicitly preserved the variability that's caused by any single parameter. Those are sampled and combined. It's essentially a numerical --

(Simultaneous speaking)

MEMBER CORRADINI: So you randomly sample whatever you don't conservatively pick as a delta function, you randomly sample through a distribution?

MR. LETELLIER: Correct.

MEMBER CORRADINI: Many, many times.

MR. LETELLIER: That's right.

MEMBER CORRADINI: You subdivide the whatever into subsets so you can look at --

MR. LETELLIER: Of results subset.

MEMBER CORRADINI: Well, the way you said it is you said you did many thousands if not more than thousands, but you had little bins of them so you could almost cross compare in terms of what the results are, if I understood correctly.

MR. LETELLIER: Well, the result is simple. It's either a success or failure, and we're looking for the proportion which represents conditional failure probability.

MEMBER CORRADINI: Right.

MR. LETELLIER: So all of the variability in a physical parameter like the filtration function has been sampled and combined in essence into this grand proportion. So we are getting a single best estimate that's integrated over the physical variability.

And we're explicitly preserving and propagating the uncertainty in the initiating event frequency. That's the 15 bins.

MEMBER BLEY: You're confusing this with what we're preserving and not preserving. And I think I know what you're talking about, but it's not, I want to make sure so let me feed it back to you. I think you're, in my sense, preserving everything, I hope.

You've got a frequency distribution, initiating event frequency distribution. You're leaving that set. You're taking your part of the model, and you have input from the PRA, which are 15 bin PDPs and you're sampling from all this stuff that's in your big model, and you're generating an output.

Then you're going to convolve that output with the initiating event frequency distribution afterwards.

MR. LETELLIER: Only one step that I would correct. It's actually CASA that samples the initiating event frequency. Let's pick a percentile of uncertainty, and we exercise in a complete statistical design.

MEMBER BLEY: For the whole thing?

MR. LETELLIER: For the whole percentile.

(Simultaneous speaking)

MEMBER BLEY: So then what do you mean by saying you're preserving the initiating event distribution?

MR. LETELLIER: The uncertainty --

MEMBER BLEY: I think you'd be better without those words and it would make sense to us. But if they mean something, you got to present it in a way we can kind of figure it out.

MR. LETELLIER: We're talking about the quantiles of the 1829 break frequency distribution.

MEMBER STETKAR: We'll get to that later.

(Simultaneous speaking)

MEMBER BLEY: I thought you're using it against a whole model, and you're getting an output. And this is distribution based on this whole --

MEMBER STETKAR: But is it a conditional, because the PRA quantifies an initiating event frequency with uncertainty, correct?

DR. JOHNSON: Yes.

MEMBER STETKAR: Okay.

DR. JOHNSON: I get that from CASA. The

information flow is strictly from CASA to the PRA. There's not back and forth, okay? So I get the initiating event frequency and the conditionals.

MEMBER STETKAR: Do you have a medium LOCA initiating event frequency, or do you have 600 initiating event medium LOCA frequency?

DR. JOHNSON: We have a distribution of medium LOCA initiating event frequency.

MEMBER STETKAR: Okay, and that's a single initiating event?

DR. JOHNSON: Yes. It's called medium LOCA.

MEMBER STETKAR: You whack the model with that single initiating event.

DR. JOHNSON: Right.

MEMBER STETKAR: And there are top event split fractions called sump and boron that have uncertainty distributions for the conditional probability of failure for that initiating event uncertainty distribution. Is that correct?

DR. JOHNSON: Yes. And the pump state your in and conditional on a lot of things.

MEMBER STETKAR: Again --

DR. JOHNSON: But yes, yes.

MEMBER STETKAR: Because they don't know about pump states.

DR. JOHNSON: Yes. Actually he does.

MEMBER STETKAR: He does, but you write the rules that in this pump state you use this site.

DR. JOHNSON: Right.

MEMBER STETKAR: Fifteen bin history.

DR. JOHNSON: Yes.

MEMBER STETKAR: How are then the initiating event uncertainty and the uncertainty in the split fractions, or I'll take sump, are they correlated, are they not correlated?

DR. JOHNSON: They are not correlated in the PRA.

MEMBER STETKAR: They are not correlated, but -- they're not correlated?

DR. JOHNSON: No, they're not correlated. They are in CASA, and that's something we talked about, how to --

MEMBER STETKAR: That may explain then why, because if I look at your base case, you know, perfect plan results, there's uncertainty on that. Then if I look at the post GSI 191 evaluation, the uncertainty is essentially identical.

In other words, the CASA analyses do not add any uncertainty, which to me is curious because fairly uncertain processes like strainer plugging and stuff like that would seem to increase my overall uncertainty.

And I wonder because they're being treated as conditionally independent is why it might just be fortuitous that you aren't seeing that.

MR. LETELLIER: But your insight does explain my statement that we've integrated all of the physical variables into a best estimate of failure probability.

MEMBER STETKAR: You know, I wish you wouldn't use those terms because they don't mean anything.

MR. LETELLIER: I'm sorry.

DR. JOHNSON: No, but it is true that there's no correlation between the initiating event frequency category though, medium or large.

MEMBER STETKAR: Right.

DR. JOHNSON: And the split fractions downstream addressing sump or boron in the PRA.

MEMBER STETKAR: For sump or boron?

DR. JOHNSON: Right.

MEMBER STETKAR: But in principal there is because of the way --

DR. JOHNSON: Principally there is.

MEMBER STETKAR: Because of the way CASA is doing the math.

DR. JOHNSON: Yes.

MEMBER STETKAR: Okay. I have to think about that.

MEMBER BLEY: Well, you've thought about it.

DR. JOHNSON: Yes, of course.

MEMBER BLEY: What's the impact of that?

DR. JOHNSON: I don't think the impact is significant. I think it should be represented.

MEMBER BLEY: Should be what?

DR. JOHNSON: Should be represented, because the way we do the delta, you know, we have a huge --

MEMBER BLEY: So you don't think there's something from the tail's missing because --

DR. JOHNSON: No, I don't, no. I don't think something from the tails, but we may be underestimating the delta.

(Simultaneous speaking)

MEMBER STETKAR: See, the arguments you

use about the delta, looking at those uncertainties, are pretty compelling. That's kind of a neat little story. But if for some reason those tails are underestimated because of some sort of, you know, lack of correlation or something, the overall conclusion might still hold, but --

DR. JOHNSON: It's something we've talked about, yes.

MR. LETELLIER: Let me plant one more seed for you to consider. If we have 100,000 scenarios that have, let's say, adequately sampled all of the physical variables, what is your single best estimate of failure success?

MEMBER STETKAR: You know, I'm not interested in MI. I'm not interested in best estimate. I care about uncertainty distributions.

MR. LETELLIER: Right.

MEMBER STETKAR: A best estimate is a mathematical parameter that comes out of an uncertainty distribution. So I don't care, I care that you're characterizing the uncertainty accounting for propagation of that uncertainty and if there are correlated uncertainties, you call them epistemic, you call them state, you can give them any kind of name you want to give them.

MR. LETELLIER: Yes.

MEMBER STETKAR: That indeed the way that the uncertainties are being propagate through the model correctly accounts for those correlations because if you don't do that, you can underestimate the uncertainty, and your derived mean value might be wrong because the derived mean value comes from the risk model pushing everything through, you know, plucking off mean values that you call in your point estimate quantification, but once you propagate the uncertainties, plucking off the mean value from those overall results.

DR. JOHNSON: We need to look at the correlation question. Good observation.

MEMBER STETKAR: I'll have to think. Is the overall uncertainty, I didn't get a chance to read all of Volume 3. Is that overall uncertainty combination process described in Volume 3? I skimmed through it and nothing jumped out at me, I mean, other than fairly high level discussions that you're saying, that everything is integrated and everything is fine and we came up with a mean value estimate and everything is wonderful.

MR. LETELLIER: Well, that may be the extent of the explanation. I'm afraid that we haven't partitioned physical variability into an identifiable contributor because of the way we've focused on our mean estimates.

As you said, the only variability that you find in the conditional failure probabilities is due exclusively to the initiating event. Nothing has been preserved explicitly. It's all been collapsed into the mean.

MEMBER STETKAR: Oh, well wait a minute. I read those words once, and I eventually got to the point where I said okay, those words don't mean anything, let me think differently.

Now I don't understand what you're telling me 45 minutes ago where I had a 15 bin uncertainty distribution for my, I'll do it this way, for my initiating event frequency, and I had 15 bin conditional probability distributions for each of my top events. That's what I thought I was supposed to be understanding.

But when you're saying that the uncertainty in these 15 bins conditional probability for, let's call it sump, is the uncertainty in the initiating event, then I don't understand how they're multiplied together in the PRA model because it sounds like I'm multiplying X by X, that they're fully correlated.

DR. JOHNSON: No, they're --

MEMBER STETKAR: Follow me?

DR. JOHNSON: Yes.

MEMBER STETKAR: First I thought it was just a single number. I had a big question about oh, well geez, why no uncertainty? And then I saw five bins, and today I've heard 15 bins.

MR. LETELLIER: I think we understand the nature of the communication gap. So if we may, can we come back --

MEMBER STETKAR: Okay. Yes, you know, I agree, that's fine.

DR. JOHNSON: But I guess one clarification. If there is a distribution for describing the zone of influence for example, that parameter is completely sampled within CASA. I got that.

MEMBER STETKAR: And some distribution of stuff comes out of that, and you throw it -- no, I got that. Anyway --

MEMBER BLEY: And CASA is like it shows on your cartoon, sending distributions back to the PRA to be used, not just mean values.

MEMBER STETKAR: That's what, if I read the report, someplace it sounded like a single number, and I said oh my God, this sounds crazy. Then I found five bins and I said okay, well there's at least some --

MEMBER BLEY: And now Bruce said we're only keeping the mean.

MEMBER STETKAR: Yes. That's correct. That's back to the original --

MEMBER BLEY: Confused us.

MR. LETELLIER: The real question is ask yourself what is the root, what is the basis for the percentiles of the distribution, and what is the basis for the mean?

MEMBER STETKAR: Bruce, the simple way I think of it is here is the 37.765 percentile of the initiating event frequency distribution. CASA doesn't care that that's the 37.765 percentile of initiating event frequency distribution. For the conditions that CASA's modeling, there is an uncertainty distribution about the likelihood of the sump plugging.

MR. LETELLIER: So let me correct the first statement. So remember that the shape of the, we need to get into our figures on initiating event frequency, but --

MEMBER STETKAR: We'll get there eventually because you've got more stuff on that.

MR. LETELLIER: The distribution by size is indeed very relevant to the distribution of performance. So CASA actually picks the 37.765 percentile and executes an analysis on that. And that way, we can properly account for that distribution frequency by size.

MEMBER STETKAR: Let's just leave it and just put it as I'd really like to understand it.

DR. JOHNSON: We agree that the PRA needs to correlate between the split fractions and the initiating event, we can agree at that point.

MEMBER STETKAR: Okay.

DR. JOHNSON: So a couple of other points about the analysis I thought it would be worthwhile to bring up to make you aware of is of course, you know, some of these phenomenon could last for over a period of days, 30 days for example, and yet, we're using a model that nominally has a 24 hour mission time, which is a convention.

But what we chose to do is use these foot fractions, no matter how they came to us, that represent a 30 day window nominally and append them to this PRA which has a nominal 24 hour mission time. And why don't we do that?

Remember, we're working off of, we're adding failure branches to otherwise success states, okay? So you could extend those branches off, in principal, for 30 days and have recovery --

MEMBER BLEY: Just --

DR. JOHNSON: Let me just finish.

MEMBER BLEY: Okay. I want to come back to that.

DR. JOHNSON: Okay. But what we're after is ultimately is calculating a delta CDF and a delta worth so that what we're not looking at are additional, although small, frequency non-GSI 191 failures.

Okay, so we're maximizing or overestimating the delta by not considering non-GSI 191 failures in the long term. Okay, so we are including long term effects from the sump or from the in-vessel effects onto a model at a nominal 24 hour mission time.

MEMBER STETKAR: And that, it's not described very well in the front end of the report. It's described really well in, I've forgotten whether it's Section 8 or Section 9 of Volume 2.

DR. JOHNSON: Right.

MEMBER STETKAR: And Bruce, when you run CASA Grande, how long in calendar time do you run the simulations, as I call them?

MR. LETELLIER: So unfortunately, there was a mis-match in these two assumptions. We actually run to 36 hours --

MEMBER STETKAR: But you only run up to 36?

MR. LETELLIER: That's true.

MEMBER STETKAR: Okay, now this is where a little bit, I don't want to hang up on the 24, but there's a statement made that in the nice description in, I've forgotten because I've lost my notes here, Section 8 let's say of Volume 2 --

DR. JOHNSON: Volume 2, right.

MEMBER STETKAR: -- that talks about this issue, the 24 hours. And it says well, you know, and I understand what you're trying to say here. But the statement is despite the fact that we're only using 24 hours, CASA Grande accounts for the full integrated time or something to that extent. You're saying no it doesn't, it's only 36 hours.

MR. LETELLIER: Let me explain. We have

examined that calculation time as a parameter study, and we find that the risk doesn't change appreciably even if we reduce the calculation time to 18 hours, and the reason is --

MEMBER STETKAR: No, I'm thinking extend the flow out to, oh, six months and see how it changes.

MR. LETELLIER: Yes. The reason is because we've compressed the long term effects, and in particular chemical effects which you might assume would take the longest to manifest, we've compressed them into a simple precipitation temperature.

As soon as the temperature falls below 140 degrees, the entire effect of chemical head loss is manifest. So we've compressed the time --

MEMBER STETKAR: That wouldn't get any worse, you know --

MR. LETELLIER: That's the idea, that's the intent.

MEMBER STETKAR: Okay.

DR. WALLIS: Could I interject? If you go on a very long time, you'll find your loop fields will fill up?

MR. LETELLIER: Not --

(Simultaneous speaking)

DR. WALLIS: -- something changes after a long time, since you're talking about a long time. You can't just say there's nothing is going to happen that's different.

MR. LETELLIER: If there's an additional failure mode that we could have missed, that's possible.

MEMBER BLEY: Keep saying you split up your success states and added failure states. And it's really a two step thing. You expanded the states you're looking at so that you'd pick up all the combinations of pumps that you might not have needed for a core melt model, and depending on what comes out of CASA Grande, some of those may or may not be failures because of what happens to the sump.

MALE PARTICIPANT: That's true.

MEMBER BLEY: Okay.

MEMBER STETKAR: That's not this one.

MEMBER BLEY: No, no. Following up on something David had said a few minutes ago.

MEMBER STETKAR: Okay. But you're convinced that running longer, at least for the things you've looked at, running longer than 36 hours wouldn't make a difference, and indeed you've run it to 36 hours.

MR. LETELLIER: And longer. We've done both directions and --

DR. JOHNSON: And impressed the effects of chemical effects into that time period.

MR. LETELLIER: Yes, exactly. That finding is predicated on our assumptions about the physical behavior. So we really need to examine those before you can judge validity of that cutoff time. But within the constraints of our assumptions and our models, the result is not sensitive to that beyond 18 to 20 hours.

MEMBER BLEY: Because for the things you're looking at, you've moved off of them?

MR. LETELLIER: That's correct.

DR. JOHNSON: I'd like to say a couple words about meeting the requirements of Reg Guide 1.200. So our text has been peer reviewed to Rev 1 of 1.200. Okay, it does not have an up to date seismic or fire PRA.

And what we did is we develop a process of going through and identifying those elements of the PRA that are relevant to answer GSI 191 and looked carefully at those. And the bottom line is the fire and seismic don't contribute so that even though they're certified, if you will, to Rev 1, they meet the corresponding or relevant requirements of Rev 2. Okay, I mean, just --

MEMBER STETKAR: Question. You're going to talk about results?

DR. JOHNSON: Yes, maybe, I don't know.

MEMBER CORRADINI: We were talking about 15 bins for so long, I wasn't sure.

DR. JOHNSON: So I just have a couple of slides on high level results. These are, I think, taken from Volume 2. But the top boxes compare the initiating event frequencies from the model of record, worked with the GSI 191 PRA.

And again, this is just a different interpretation of 1829, right, in terms of characterizing the initiating event frequency. Okay, if my eyes were a little bit better, I could probably say that, you know, small LOCA frequency's a little bit higher than the model of record, medium LOCA I think is just a shade smaller, large LOCA is larger than the model of record. Again, that's just different interpretations of the 1829 information.

And overall, John's correct. We just looked at mean values for the base case of the GSI 191. That's without the GSI 191 phenomenon to compare it against the with the GSI phenomenon, the differences are small.

DR. WALLIS: How big is the uncertainty on these large LOCA?

DR. JOHNSON: On the large LOCA frequency? We'll get to the large LOCA frequency distribution. I don't have that.

MEMBER STETKAR: Ninety percent confidence interval is a factor of 133.

DR. JOHNSON: Yes, it's pretty large. It's a small number, but pretty large. Okay.

MEMBER STETKAR: So it is large. I mean, there's largeness with this.

DR. JOHNSON: I wanted to point out on that last slide that we are using 1.174 as kind of a framework to judge, you know, these changes. And it's a little bit of a different application, 1.174. We're comparing the as-is plant versus a hypothetical perfect plant.

So we're not trying to move in one direction, which is 1.174 was created, but we're using that framework to judge the delta as being okay or not.

DR. WALLIS: If you wait for 100 million years, something else is bound to happen.

DR. JOHNSON: Oh, absolutely. It might mean that large LOCAs aren't worth worrying about too much. Yes, sir?

MEMBER STETKAR: Now because you've now walked yourself into -- when I looked at, I understand these results, I see them. When I look at the tabulations of results, Table 4-7 for example, and there's a discussion of the individual sequences in there, what the contributors are, I noticed a few things I had questions about.

First of all, if you look at sequences one, two, and three, I understand those sequences. I don't find, and I can't find, sequence number four which ought to be the other incarnation of the logically same combination of things.

Those, to refresh your memories, sequences one, two, and three occur with the LOCA and the cold medium LOCA in either Cold Leg A or Cold Leg B with one train not of that loop, out of service for maintenance.

And I get three of the four possible combinations. I don't see the fourth combination. There are four possible combinations, in my mind, that can go to core damage.

DR. JOHNSON: I don't have that in front of me. I'll have to get back with you on that.

MEMBER STETKAR: Not there. So that's one question I had. Second question is there's something that said well, we have modeling assumption that says well, you know, if the LOCA occurs in Cold Leg C, none of this flow bypass occurs because we've made a modeling assumption.

And to me, I really don't get that. There are no sequences with a break in Cold Leg C where I have either train, where I have Train A or Train B out of service for maintenance, which is the third logically common.

So I count three sequences, I can understand them. I can't find the other three that I would expect to find at essentially the same frequency. That obviously effects the base case, it effects -- but it points to some sort of embedded rules or modeling assumptions that may not effect the particular comparison I'm looking at, but they could effect other things if they're pervasive because they're sorting out what combinations of stuff is up and down. So take a look at that.

MR. LETELLIER: We'll look at that.

DR. JOHNSON: Let me call your attention --

MEMBER STETKAR: And that's why I ask, you know, okay, you've got a peer reviewed PRA. Peer reviewers didn't look at this? Did they look at your split fraction binning rules, did they look at the symmetry of the results, did they look at the logical combinations of things that ought to have been there and weren't?

DR. JOHNSON: I can't answer that.

MEMBER STETKAR: Okay.

DR. JOHNSON: Let me call your attention also to another good RAI from the staff was they said okay, this list is a list. But give me the top X number of sequences that involve GSI 191. So there's another list you can look at to get further insights on the RAI response process.

MEMBER STETKAR: Were the top X number for --

DR. JOHNSON: Just a listing of sequences involving 191 phenomenon.

MEMBER STETKAR: Yes, okay. So you screen out the -- yes, but --

DR. JOHNSON: I understand --

(Simultaneous speaking)

MEMBER STETKAR: My problem is if there's something more foreign than metal, that's going to effect --

(Simultaneous speaking)

MEMBER STETKAR: You don't see that in the list in the report because they're only a handful or so of GSI 191 sequences in there.

DR. JOHNSON: Right. In the RAI response, you'll see nothing but our GSI 191. We'll check the rules there.

MEMBER STETKAR: Okay.

DR. JOHNSON: And you've heard it before, but this last sub-bullet here is that the non-bounded nature of some scenarios with the analyzed pump states contributed about 25 percent of the bulk of CDF.

And granted, we need to go back and look at the correlation of CDF, but when we ran the uncertainty distributions through the whole model, we were able to put a confidence bound on the delta CDF at a 95 percent level.

I think I spoke to this, using 1.174 as comparing the as-is with a perfect plant, if you will, as a bounding case. And, you know, 1.174 has a number of attributes to it. The CDF and LERF, et cetera, delta CDF, delta LERF are only one element of the comparison that needs to be made, analysis could be made.

But you know, from the point of view of the numerical metrics, if you will, conclusion is we're in region three. The submittal looks at the other aspects of 1.174, the defense in depth, and that's, I don't have slides on that right now.

So unless there's more questions on PRA, we'll skip to the LOCA size distributions.

CHAIRMAN BANERJEE: So may I suggest something that --

MEMBER STETKAR: Let me ask one --

CHAIRMAN BANERJEE: Sorry, go ahead. Yes, go ahead. Finish up.

MEMBER STETKAR: It's still my meeting.

CHAIRMAN BANERJEE: No, it's your meeting this far. Go ahead. I'm going to change the topic.

MEMBER STETKAR: I know.

CHAIRMAN BANERJEE: But I was going to do, like, size frequency and selection next.

MEMBER STETKAR: Yes, that would be excellent, yes.

(Simultaneous speaking)

MEMBER STETKAR: Let me ask one thing on the PRA. The statement is made, well the full power of PRA models bound low power and shutdown conditions. And I got the low power stuff because that's fine.

The only thing I could think about in shutdown is are there, during an outage, when do you open up the containment? And I don't necessarily mean break containment integrity in a legal sense. But when do you start to unpack stuff in the containment and get bins of stuff out there for protective clothing?

For example, if it's during plant operating configurations where RHR is operating, the system is closed, and you're pressurized to, pick a number, 400 pounds. I forgot your interlocks. You still have 400 pounds of pressure in the system, and you might have a lot more stuff inside the containment to get mobilized.

Now, if you don't typically start unpacking stuff until your, you know, cold invented, I'll buy the full power operation bounding the shut down stuff. That's the only question I had about, you know, the big discussion about scope of the PRA, why we don't need to consider shutdown.

MR. KEE: You know, we can get schedules of what takes place, we probably ought to do that.

MEMBER STETKAR: It's most, you know, if we're talking about unsecured stuff --

MEMBER BLEY: Right, exactly. Yes. It's really what do your admin procedures require before you start up and then that stuff up.

MEMBER STETKAR: Well it's when, you know, if they're getting ready to do a bunch of maintenance.

MR. KEE: Yes, procedurally. We can get that.

DR. WALLIS: Are your sequence frequency truncation limit is 10^{-14}?

DR. JOHNSON: Yes.

DR. WALLIS: What's the probability of a sequence you didn't think of? Isn't it bound to be bigger than that?

DR. JOHNSON: Yes, I mean, you have to remember this is using a scenario based model that these scenarios aren't minimized, if you will. There's some artificial fracturing going on by the way that questions are asked.

So you know, in principal there could be a 10^{-10}, just making up a number, a number larger than 10^{-14} that's not imbedded here somewhere. Mr. Stetkar pointed to a possibility. But if we can get comfortable with our rules, et cetera, on the base model, I don't think we're missing anything significant.

CHAIRMAN BANERJEE: Okay. Maybe, Mike, we can move on to LOCA size and frequency next, and then take all the other things up to that.

MEMBER STETKAR: Let me ask one more.

CHAIRMAN BANERJEE: One more this the last.

MEMBER STETKAR: One more, oh I only get one more. Okay, let me ask this one then. In the medium LOCA, early medium LOCA event tree, there's a top event called CP, it's isolation of the normal large containment ventilation print.

And it distinguishes whether or not that's success or failure. Does CASA Grande in the evaluation of available net positive suction head assume that the containment is isolated, and if so, if a large hole is available in the containment, would that effect your determination of available net positive suction head given whatever strainer plugging scenario you have.

MR. LETELLIER: So we've recently discussed this exact issue. Maybe not the operational context that you just described, but the issue of containment isolation.

The only assumptions about containment pressure that CASA assumes is that if the water exceeds 212 degrees, then we assume the containment pressure is at saturation.

MEMBER STETKAR: So you do take credit for saturation pressure?

MR. LETELLIER: For saturation pressure. As soon as it falls below that, we assume it's at atmospheric as if the containment were open.

DR. JOHNSON: Not taking credit for containment pressure for NPS, for NPSH.

MR. LETELLIER: For any time period beyond that. And we'll show you an example of NPSH available where you can see how margin is --

MEMBER STETKAR: Yes, I was going to say the margins would help there some, thanks.

DR. JOHNSON: But that has been flagged for a detailed discussion.

MEMBER STETKAR: Okay.

MR. LETELLIER: And I think that simply becomes an additional failure state, if you will.

MEMBER STETKAR: Yes, it is. Well, that's why I was -- I have no idea what the frequency is. But the PRA does track that for a variety of reasons. Okay.

CHAIRMAN BANERJEE: Are you done?

MEMBER STETKAR: That's all I've been allowed.

CHAIRMAN BANERJEE: Dennis?

MEMBER BLEY: I get one more.

CHAIRMAN BANERJEE: Okay.

MEMBER BLEY: A couple times, like with the operator actions and some other things in the discussion, we say well we did that early on but we knew we'd have to deal with it later, is there an envisioned point at which there will be a revised analysis to take care of these things, and is that figured into anything in the NRC's review of this submittal?

MR. KEE: We've discussed doing a quantification with staff later this year or early next year. But we haven't made any decisions along those lines. But we do recognize that we want to, as a consequence of the RAI process and so on that we want to probably capture a lot of the comments and changes that may have come out of that process in a final kind of a --

MEMBER BLEY: That would be really helpful. But I just wondered what your plans were, but you haven't really decided that yet.

MR. KEE: No, there's no final, there hasn't been any final discussion on that, but it seems reasonable that we would eventually --

DR. JOHNSON: We expect more RAIs, another batch of RAIs, right? So it doesn't make sense to plan that until we have everything on the table.

MEMBER BLEY: Okay.

MR. LETELLIER: In some sense, we're seeking consensus on some important issues. This is a pilot project. We're forging new ground as far as methodology goes, so we're accepting all input from all expert.

DR. JOHNSON: Now can I go?

MEMBER BLEY: Okay by me.

DR. JOHNSON: All right.

CHAIRMAN BANERJEE: All right, we're just running maybe an hour behind time now? That's not unusual. So we'll try to make it up, but let's move on to the LOCA, and then we'll take all the head loss in-vessel chemical effects all together more or less, one after the other, whatever order you like which is most logical.

(Off record comments)

DR. MORTON: So I'm David Morton from University of Texas. And so I'd like to say a word about modeling LOCA size and frequency. And so I've got a pair of slides here and then I'm going to hand off to Bruce who will say a bit more about sampling strategies from the distribution I'll describe within CASA.

And so what we're really talking about here is a joint distribution governing the frequency and the size of the LOCA. And so NUREG 1829 is where we start with this. And so just to remind of, you know, what is 1829 consist of.

So it's an expert elicitation. That expert elicitation was done at three break sizes. Exceedance frequencies were elicited. Those break sizes were 1/2 inch, 1-5/8, 3, 7, 14, 31 inches.

And there were three percentiles that were elicited that were the 5th, 50th, and 95th percentiles.

DR. WALLIS: Those were six breaks.

DR. MORTON: Six break sizes total. Yes, six break sizes and three percentiles.

DR. WALLIS: It would be useful if you would actually show us that variant because we could figure from that. That really is --

MEMBER STETKAR: The results are tabulated. We'll get into it more.

DR. MORTON: There's a table that starts at say the median value --

DR. WALLIS: But in the slides here.

DR. MORTON: No, the table's not in this.

DR. WALLIS: It's quadramatic to where it falls down with size.

DR. MORTON: All right, so basically an order of magnitude drop says you go from 1/2 inch to 1-5/8 to 3, 7, 14, 31. And then this was just alluded to there, there's significant variability from say the 5th to 95th percentile within each break size.

We model a continuous distribution. And so the question is joint distribution, how we construct it. You can basically understand this by answering three questions.

So first, within a fixed break size, given that there are just three percentiles that are elicited, how do we fit a continuum of frequencies? That's the first question.

The second question is so 1829 is a fleet wide elicitation, then how do we map from that, those frequencies into specific weld cases at STP? So that will be question two.

And then question three is if we really want a continuum of break sizes, but there were just six break sizes that were elicited in 1829, then how do we capture that continuum?

So the answer to the first question here is that we use what's called a bounded Johnson distribution.

MEMBER STETKAR: And my question is why didn't you use the log normal distribution that very well fits those curves?

DR. MORTON: So the --

MEMBER STETKAR: And indeed, there's a lot of discussion in NUREG 1829 about log normal. They use two-sided log normal fit, but if you take the mean value from those estimates and calculate a log normal error factor, it's amazing how closely the 5th and 95th percentiles of those curves hit. It's really close.

So the question is why did you use a bounded Johnson distribution rather than just the log normal if the log normal fits so well, because I calculate log normal's at infinitesimal points real easy.

DR. MORTON: So 1829, so what happens in 1829 is they use what they call a truncated split log normal. So that split log normal is fit to each of the individual experts.

MEMBER STETKAR: I --

DR. MORTON: There's not an aggregate. So if you just go to the table in 1829 and say oh, there's the 5th, 50th and 95th percentile, let's do a split log, let's do a log normal on both sides, then when you do that fit, you don't get the mean that --

MEMBER STETKAR: Yes, you do. I, you know, I have the tabulated numbers here. And except for when I get out to 31 inches, the 5th and, if I take the mean values and I take the ratio of their 95th to the 5th, take the square root of that, call it an error factor, take the mean in that error factor, I come up with the 5th and 95ths real easy on a log normal approximation. Certainly better than 5 bin, 15 bin histograms, they are really doggone close. I can show you what I did.

DR. MORTON: Yes, we would be interested to see because --

MEMBER STETKAR: And they're --

DR. MORTON: -- it's not consistent with what we got. In fact, the --

MEMBER STETKAR: I know it's not consistent, well, because --

DR. MORTON: No, no. It's not consistent with what we got when we did a split log normal. So when we --

MEMBER STETKAR: Yes, but you were doing a split log normal. I'm just taking a log normal. I'm taking a simple log normal. Just take the values in that table and fit a log normal to it.

DR. MORTON: It doesn't work. We tried it. And in fact, what we started with is --

MEMBER STETKAR: Let's do it offline then at the break rather than having this discussion.

DR. WALLIS: We've only got three points to fit?

MEMBER STETKAR: Defines the distribution.

DR. MORTON: That's right.

DR. WALLIS: That's pretty easy, then.

MEMBER STETKAR: Defines the distribution.

DR. MORTON: So what you can do --

MEMBER STETKAR: And it fits.

DR. MORTON: So a similarly bounded Johnson distribution is a shifted log normal distribution.

MEMBER STETKAR: Yes, I mean, you can --

DR. MORTON: And if you do that --

MEMBER STETKAR: It sort of looks --

DR. MORTON: Then the lower bound on that fit, so you have three parameters and a shift of log normal.

DR. WALLIS: You can fit it exactly.

DR. MORTON: You can fit it exactly, that's correct.

MEMBER STETKAR: You can.

DR. MORTON: And lower bound is negative. So you get a negative frequency for the lower bound of that shifted log normal.

DR. WALLIS: That's a wonderful discovery.

MEMBER STETKAR: Are you slicing it frequency space or are you slicing it sized spaced?

DR. MORTON: Here we have a fixed size, and we're fitting in frequency space.

MEMBER STETKAR: And you're coming up with negative frequency?

DR. MORTON: We get a negative frequency for the lower bound of the shifted log normal.

MEMBER STETKAR: Of the shifted log normal.

DR. MORTON: Right. So the log normal will automatically have a lower bound of zero, and we only have two parameters there, and we can't match the three percentiles of 1829.

MEMBER STETKAR: We can discuss this

offline because most people --

DR. MORTON: I mean, that's exactly what we tried initially was precisely that, but we got this negative frequency, and so that's why we shift, moved, to the bounded Johnson because then it has four parameters and we could avoid those negative frequencies that come up with the shifted log normal.

MEMBER STETKAR: Okay.

MR. LETELLIER: Do you have a graphic that might help the conversation?

MEMBER STETKAR: You do. Well, you know, I saw that graphic. That's fine. I understand that.

DR. WALLIS: But the answer is not very different in both cases.

MEMBER STETKAR: The answer isn't necessarily -- in fitted Johnson distribution it sort of looks log normally anyway. But my question is why do that, because I didn't see a real reason to do that.

DR. MORTON: So it's the negative frequency. That's why --

MEMBER STETKAR: I didn't come up and -- anyway. We can compare notes later. Are you going to talk about your interpolation algorithm, your linear-linear interpolation algorithm rather than a log linear, because that does give you a very funny looking behavior between those fixed points.

DR. MORTON: That's right. So the --

MEMBER STETKAR: Do you have a slide, are you going to talk --

(Simultaneous speaking)

DR. WALLIS: -- paper, it gives you a funny reading.

MR. LETELLIER: Just a quick clarification for everyone else in the room. The dots that you see on this plot, these are the numeric values from the table in 1829. And the question is how do we connect the dots in size.

MEMBER STETKAR: Okay, I asked you at number three. So --

DR. MORTON: Right. So we can go straight to number three because --

MEMBER STETKAR: Right, because that's a little bit, number two kind of gets into the other part of --

DR. MORTON: Number two is in the next slide.

MEMBER STETKAR: Yes.

DR. MORTON: So basically, we've already

talked about number one.

MEMBER STETKAR: Right. Yadda, yadda, yadda.

DR. MORTON: So we've talked about number one. Let's talk about number three because number two is indeed on the next slide. So suppose, so there's six, we can think of them as break categories from 1829. And suppose that we know that we're in between 3 inches and 7 inches. So we have fixed values for the distributions at 3 inches and 7 inches, but we want a continuum of break sizes.

So there are two different ways to think about this. One is that we do a linear interpolation between the frequencies at the 3 inch and the 7 inch marks. That's equivalent to saying that oh, given that we fall within this bin that's between 3 and 7 inches, we just draw a uniform random variable between 3 and 7 inches.

So what this does is it's conservative in the sense that if you're seeing this order of magnitude drop off when you go from one break size to the next in 1829, then basically you get this corrugated graph that --

DR. WALLIS: Since you started with a log plug, why didn't you use a log interpolation?

MEMBER STETKAR: If you do --

DR. WALLIS: That's why he likes the other one.

MEMBER STETKAR: If you just plot them, they're nice, smooth curves. They don't have this scalloped approach. Now the scalloped approach, you use the word conservative, I'll just use English. The scalloped approach has kind of a dramatic effect as you approach the next pinpoint. You know, your frequency kind of stays high, and then it drops off.

DR. MORTON: It conserves frequency at --

MEMBER STETKAR: No, don't use words. It just has this approach. It's not clear why the world ought to work that way.

It would strike me, given the fact that we're starting out with expert elicitation for people who thought an awful lot about LOCAs of six discreet sizes from 1/2 inch up to 31 inches, which is pretty broad range, and you know, documented what they did and said this is the best that we can do, and given the fact that the world sort of works smoothly normally, I don't understand why this scalloped depiction is better than a log linear interpolation which is what you would get to just plotting the points.

DR. MORTON: So it --

MEMBER STETKAR: And it's not necessarily conservative, it's not. It's just funny looking.

DR. MORTON: The absolute reason why we did a linear, strictly linear interpretation is because we did not want to attribute any additional information to the expert elicitation that was not intended.

MEMBER STETKAR: But you have. You've attributed this scalloped behavior.

DR. MORTON: No, we've attributed an equal probability of a break anywhere between the elicitation points. If we do log linear as you've suggested, in fact we've done that, then from a functional analysis perspective, we are actually attributing properties to the probability density function.

Remember, we're looking at compliments here, right? And so we didn't wish to, we wanted to avoid that implication of interpreting some additional information in elicitation --

(Simultaneous speaking)

DR. WALLIS: -- and I agree with John.

CHAIRMAN BANERJEE: Can you show us the points again?

MEMBER BLEY: You had a trade off of where you wanted to put something weird in here and --

MEMBER STETKAR: Do you have the scallopy looking --

DR. MORTON: Yes, we do. Yes. So the staff --

MEMBER STETKAR: The problem is I have the smooth one.

DR. MORTON: The staff should weigh in on this because it's a consensus conversation, and I would love to use a log linear interpolation. It seems to fit better with fraction mechanics, it seems to fit better with the way the world works, and it would avoid confusion with this.

MEMBER STETKAR: The concern I have is if you look at each of the distinct points are correlate to the numbers in the table.

DR. MORTON: Yes.

MEMBER STETKAR: And that sort of scalloped behavior, I don't understand why the world works that way. If the experts gave you things that were, they're not strictly linear on a log linear plot, but they're a lot more linear than this.

DR. MORTON: I'm not sure everyone fully

appreciates that these are cumulative functions.

(Simultaneous speaking)

MEMBER BLEY: I would just suggest if you fed these back to those ten experts or whatever they had and said is this what you meant, it's of course not. They wouldn't even think about it, it would be no. And I know what you tried to preserve, but I think it leads you to just a funny point.

CHAIRMAN BANERJEE: This leads you to a bit higher frequency than you would get with a log linear, yes.

DR. MORTON: At some points, yes.

MEMBER STETKAR: At some places it is, at other places it's not. You know --

(Simultaneous speaking)

MEMBER STETKAR: -- this leads to whatever it is.

DR. MORTON: At the inflection points, it's exact. The question is how do you interpolate between them.

MEMBER STETKAR: Right.

DR. MORTON: How do you distribute the frequency between them by size, between the points.

MEMBER STETKAR: But the distribution is

important because, for example, the medium LOCA size range used in the model is 2 inches to 6 inches. And you've got the three and seven points, but essentially, the vast majority of medium LOCA is derived from the interpolation process here.

Whether what they've done is numerically conservative, I have no idea. You know, this is what it is and I'm just making the observation that this sort of looks funny.

DR. MORTON: Point taken. I don't disagree with you.

CHAIRMAN BANERJEE: Okay, so I think we move on to the next slide. Your concern has been noted, I'm sure.

DR. MORTON: When you say next one, it's number two, right, because we skipped that.

CHAIRMAN BANERJEE: Yes.

DR. MORTON: Right. So one and three basically sit in NUREG 1829 space. Right, so question two goes to the issue of if you now have, if you know that you're within a particular NUREG category, then how are you going to allocate that frequency across different welds in the plant?

And so the next slide describes what we call the hybrid method for doing so. So we have three equations here. So the first equation recognizes that in 1829, we're dealing with exceedance frequencies. And so the probability that you fall within a particular category is computed as according to equation one.

So delta in the numerator between the adjacent categories and the frequency of the smallest 1/2 inch break in the numerator. And then based on ISI estimates, is there any indicative later that include degradation mechanisms and so forth?

We have exceedance frequencies so that but subscript stands for bottom up. So we, in our lexicon, we have 1829 as a fleet wide top down characterization. And then we've got this plant specific, and we call that bottom up.

And so there we have the frequency of, an exceedance frequency at a particular weld case index by I. And so then we call these weights, these with sub j. these are really conditional probabilities. So it's the conditional probability, given that I'm going to have a break that's in category J, what's the probability that we attribute it to weld case I.

And so then in the third equation, all we do is we compute this joint distribution by taking the marginal associated with the categories and the conditional derived from the bottom up, and then that way we can compute this joint.

MEMBER STETKAR: Now, I see the math, and let me ask you kind of a simple question. In Volume 3, there are sets of tables, 2.2.3 through 2.2.9, which as I understand it, 2.2.10 to be precise, as I understand it summarize the results of this process. Is that correct?

DR. MORTON: Those are summaries of the bottom up frequency assignments.

MEMBER STETKAR: That's --

DR. MORTON: That's where we've taken credit for in-service inspection, weld mitigation, and plant --

MEMBER STETKAR: Well, let me cut to what I'm confused about. Should the sum, if I look at a, let me pick a size, a 3 inch break in these tables in Volume 3 and sum up the exceedance frequencies of the LOCAs of that size, should I have then the mean frequency of a 3 inch LOCA from NUREG 1829?

DR. MORTON: No. If you sum those up, you'll get the denominator of equation two. And so those weights are basically the proportional spread across weld cases in exactly the way you've interpreted them.

But we recognize there is a mismatch. That's why we need to do this joint normalization, to properly conserve the top down frequency from NUREG 1829 and also apportion them by weld type from the bottom up.

DR. WALLIS: Was this why you compress everything in the next figure to two orders of magnitude instead of six orders of magnitude?

DR. MORTON: That's a specific example for one weld case.

DR. WALLIS: Only one weld case. But that's because you divide it by the weld, it's conditional probability? Is that what does it?

DR. MORTON: Yes. In fact that plot, if you just click over real quick, the blue line is actually a plot of one of the table entries, one of the pear wise entries in those tables.

DR. WALLIS: Which table?

DR. MORTON: I mentioned 2 --

DR. WALLIS: This was from 1829?

DR. MORTON: No.

MEMBER STETKAR: Help me again to understand the actual process. If I look at the 2.2.3

through 2.2.10 tables in Volume 3, they give me exceedance frequencies, they are frequencies of event per year for a variety of break sizes, dispartized break sizes like 1/2 inch, you know, 1-1/2 inch, whatever.

For each of, and I won't bother counting them up, a number of different weld cases --

(Simultaneous speaking)

DR. MORTON: -- conditioned on weld.

MEMBER STETKAR: -- Forty five --

DR. MORTON: Forty five some odd weld cases, and the numbers you're looking at should be precisely those values there. The bottom up exceedance frequencies, given that we're talking about each of the 45 weld cases in turn.

MEMBER STETKAR: Now, okay, and so for example, if I take a 3 inch break size among all of those entries, across all of the weld cases and sum those frequencies, sum those exceedance frequencies, what does that sum mean? I mean, how is that sum derived?

DR. MORTON: So --

MEMBER STETKAR: Because it certainly doesn't match the NUREG 1829 number, so that's --

(Simultaneous speaking)

MR. KEE: Can we just back up to what the objective is? So we want to preserve, say, let's pick an elicited break size from 1829. We want to preserve that overall.

MEMBER STETKAR: Yes.

MR. KEE: But this, these tables that you're looking at are, from industry experience with O, we saw there's cracking in this, let's say like an alloy 600 weld. Oh that crack, man, every time I look, it cracked or something.

And so we're trying to take that into account. This is, like, big picture. Take that into account while we preserve the 1829 frequency. So where we see these kinds of degradations in our plant, we're adjusting to that.

MEMBER STETKAR: Okay. I get, you know, I get the physics. What I don't understand yet is the math. Let me give you, go back to specific numbers. If I add in those tables the exceedance frequency for 3 inch breaks, however it's calculated, whatever bottom up stuff, it comes out to be about 3×10^{-6} event per year. I added it up.

The exceedance frequency for a 3 inch break in NUREG 1829 is about 1.6×10^{-5} per year, or roughly a factor of five times higher. How does the overall PRA preserve that NUREG 1825 frequency and appropriately allocate that frequency back among all of those 45 three inch break cases? That's what I'm trying to get to.

DR. MORTON: Right. And so here's how that happens.

MEMBER STETKAR: Because I couldn't do it from those tables, but I didn't see how else that was done.

DR. MORTON: So first, you can't use that exceedance frequency itself. We need to take a delta between that exceedance frequency and whatever the next largest break size is, okay?

MEMBER STETKAR: Yes, yes. I'm fine.

DR. MORTON: So first we do that. And then --

MEMBER STETKAR: I'm just looking at points.

DR. MORTON: Right. So now, if we take this weld case and we take that weld case, and the frequency for this one is twice the frequency for that, then given that we've had a break in this category, then it's twice as likely to be located, allocated to this weld versus that weld. That's it.

MEMBER STETKAR: So all you're doing is

using these frequencies as a, the frequency doesn't mean anything.

DR. MORTON: It's the relative likelihood.

MEMBER STETKAR: Okay. Thanks. If it had been presented that way rather than frequency, and described, rather than relative frequencies of break size with exceedance frequencies in terms of events per year, just saying well we use this stuff and eventually divide it out about a number so that this one is 2.752356 and this one is 1.25352, and the other, you know, A is about twice as big as likely as B, I'd have understood it.

DR. MORTON: Okay, okay, okay. I got it.

CHAIRMAN BANERJEE: Can we move on now?

MEMBER STETKAR: Yes.

DR. MORTON: Certainly. Maybe the final thing I could say here is that there were discussions earlier of conditioning on percentiles --

DR. WALLIS: On the next slide, 60, are you going to get to that? Are you going to get to 60, this thing with the blue line --

DR. MORTON: Yes.

DR. WALLIS: Are you going to explain that?

DR. MORTON: Yes. All right --

DR. WALLIS: Oh, he will?

DR. MORTON: I was just, the only point I was going to make was that given this distribution, now we're in a position to condition. So when we're using this word preserve, I mean, we mean that we're going to condition on, for example, a particular percentile. And so now we can produce, for example, conditional delta CDF estimates, conditioned on the 37.5th percentile of 1829.

CHAIRMAN BANERJEE: Can we get to the next slide?

(Off record comments)

MEMBER STETKAR: With us, you'll learn that silence, believe me, means go as fast as you can.

MR. LETELLIER: Okay, I think we understand the objectives for the top down conservation of total frequency and the bottom up assignment to specific core stations in the plant.

So now the question arises is how do you choose the break sizes that you wish to simulate? And so what we have here in the blue line is one of these tables that was mentioned earlier in Section 2.

This is for a specific weld case, Case 1B, and this is a conditional, condition on being in that weld case, it's a conditional cumulative distribution of annual frequency by size for a single weld or a single weld category.

DR. WALLIS: So Case 1B is a particular weld in a particular pipe somewhere?

MR. LETELLIER: It's a family of welds --

DR. WALLIS: A family.

MR. LETELLIER: -- that share attributes.

MR. KEE: So there's, like, four loops. And so you'll find symmetry, let's say four locations, for example, that's what. And that case would apply.

MR. LETELLIER: So obviously we're always interested in the double ended guillotine break condition because it has the greatest probability or potential to challenge the safety systems.

We always include the DEGB endpoint. In fact, we do a little better than that. We assume that if in random sampling we select a break size that's greater than the pipe diameter, we just let that scenario proceed to the DEGB condition so that we have a spherical zone of influence to maximize debris.

But we actually want to interrogate alternative breaks on the same weld, and that's because of its interaction with targets. We have insulation material that's very discreet that it lives on the pipes. It can be nowhere else. And so --

DR. WALLIS: It's on the steam generators too, isn't it?

MR. LETELLIER: That's right.

DR. WALLIS: That's where most of it is.

MR. LETELLIER: It can be in proximity to very large blankets of insulation. So we set up a stratified sampling strategy that actually emphasizes large breaks without biasing the statistical outcome. And this is standard practice in any kind of, in many physical science and engineering approaches.

When you have a very small result and it's very difficult to get to you, you do a splitting or a sampling strategy that allows you to get information about those remote failure conditions, but at the cost of very small contributions to the overall probability. And that's what we've done here.

So this is the algorithm. It could have been done a dozen different ways, but this is what we did. We allowed the user to pick a number of breaks on the very largest pipe. And in this case, it's an example with ten breaks, ten large breaks on the largest pipe.

And those are defined by the increments in the vertical dashed lines. There are nine intervals plus one for the DEGB, represents ten. And if you trace these vertical lines to the CCDF and left along the horizontal axis, then the deltas in the horizontal dashed lines, those are the probability weights that are assigned with that scenario.

You can see that there are only two intervals in the medium break range, and that was simply selected in proportion to the physical range, the definition of medium to large. We can never have less than one break, and so there's always at least one small break that's simulated at this weld.

So that's the algorithm, and this is repeated for all weld cases in containment. And then this aggregate probability is distributed uniformly to all of the welds in that case.

DR. WALLIS: So why does it collapse things? I mean, in the large break, if you look at the range between whatever it is here, 5 inches to the biggest, and you've got a much bigger range than 1829 than you have here for frequency. The range for this is two orders of magnitude or something in 1829. Here, it's a very narrow range. Why is it collapsed so much here?

MR. LETELLIER: Can we pick specific sizes?

DR. WALLIS: Well, I'm looking at the large break starts, that looks like 5 inches here.

MR. LETELLIER: Yes, 6 inches, yes.

DR. WALLIS: One, two, three, four, six. Okay, but over that line, the large break range, 6 inches to if you look at 1829, the frequency drops by two orders of magnitude or something. Here, it drops by, you know, hardly anything factor, 1/2 or something.

MR. LETELLIER: So remember, this is the bottom up perspective.

DR. WALLIS: I know. That's why I don't quite understand why it collapses so much.

MR. LETELLIER: The total break frequency that you're looking at in 1829 has been spread across all of the pipes that can support breaks at that size.

DR. WALLIS: I understand that, I understand that.

MEMBER STETKAR: Be careful because I think I heard you just saying what I asked earlier, which is not what I thought you were. I'm understanding that the bottom up, maybe I've got it wrong again, that the bottom up uses some sort of calculator.

That calculator is programmed to use some sort of units, and it has some sort of algorithm in it, and that calculator says that a 3 inch break in Category 1A has some number associated with it. And it says that a 3 inch break in Category 1C has a different number associated with it.

And the ratio of those numbers is effectively the likelihood, conditional likelihood that I'd have a 3 inch break in 1C versus 1A. Now, those relative likelihoods are then somewhere, somehow, which I couldn't find, but somewhere, somehow apportioned to the actual frequency of a 3 inch LOCA.

MR. LETELLIER: Yes.

MEMBER STETKAR: Such that when I add up all of these, I'll call them relative likelihoods, when I add up all of these probabilities, they sum to one, and the frequency is whatever's in NUREG 1829. Is that correct?

MR. LETELLIER: That's absolutely correct.

MEMBER STETKAR: Okay, okay.

MR. LETELLIER: And the behavior you're noticing is --

(Simultaneous speaking)

MEMBER STETKAR: Unfortunately, the way it's presented here and in the report, the calculator uses this number that's called a frequency, and it gets confused with NUREG 1829. It doesn't really --

MEMBER BLEY: If these were all presented as relative likelihoods, and then you scaled it by --

MEMBER STETKAR: And you scaled it --

MR. LETELLIER: And in fact, that is the very first step in CASA Grande.

MEMBER STETKAR: Yes, okay.

DR. WALLIS: Thank you.

(Simultaneous speaking)

MEMBER STETKAR: Because if you read the words, and if you read the words and you hear the presentations, you are indeed led to believe that those numbers in those tables and the numbers on this plot here have some relationship to NUREG 1829.

MR. LETELLIER: I do understand that.

MEMBER STETKAR: And they don't.

MR. LETELLIER: I do understand that. We're, for traceability --

MEMBER STETKAR: The little fractions eventually do, but --

MR. LETELLIER: For traceability sake, we're presenting the raw data in the format it was provided.

MEMBER STETKAR: So somebody else's calculator calculated these numbers using something or other, and you said that's a good enough calculator for us.

DR. WALLIS: But using that process, I don't understand how you collapsed everything so much. But, you know, I'm not going to get into that. We can't get into that now. I don't know how you managed to collapse it so much.

MEMBER STETKAR: It's this is the algorithm from that calculator.

CHAIRMAN BANERJEE: Okay, I think we are done with this section, now.

MEMBER STETKAR: I actually get this.

MEMBER CORRADINI: You look happy.

CHAIRMAN BANERJEE: Well, I just want to be only one hour late today, not one and a half. Could we move on to the next topic, whatever you want to pick? We've got 15 minutes to get through it before, pick one which will be done in 15 minutes, please.

MR. KEE: Yes, it's just quick, we want to do this in-vessel and we'll show that picture and then move on.

CHAIRMAN BANERJEE: I think chemical effects might need more than 15 minutes. But maybe not. Let's do the chemical effects.

(Simultaneous speaking)

MR. KEE: It's really quick.

CHAIRMAN BANERJEE: Great, thank you.

MR. KEE: And we've covered most of this already.

CHAIRMAN BANERJEE: Well, in-vessel goes on for ever. You can present what you like. I don't think it will make any difference.

MR. KEE: All right, so we do have this --

(Simultaneous speaking)

MEMBER STETKAR: Give him a fair hearing.

CHAIRMAN BANERJEE: We'll give you a fair hearing right now, and again, and again, and again.

MR. KEE: So I think everything on here we've already discussed on this first slide. So unless we want to see something here that we want --

CHAIRMAN BANERJEE: Have you done any experiments?

MR. KEE: For? As a scale vessel

experiment?

CHAIRMAN BANERJEE: Yes, whatever. Any experiments, or are you just using stuff that somebody else has done? We've seen almost everything other people have done.

MR. KEE: Not an experiment --

CHAIRMAN BANERJEE: You've done nothing specific.

DR. WALLIS: No experiments?

MR. KEE: For in-vessel.

DR. WALLIS: Because every time we see new experiments from someone --

CHAIRMAN BANERJEE: Well, you find a new phenomenon.

(Simultaneous speaking)

CHAIRMAN BANERJEE: It goes the wrong way, that's right.

(Simultaneous speaking)

CHAIRMAN BANERJEE: I think it's better that you didn't do any.

MR. KEE: Yes, or better to analyze.

CHAIRMAN BANERJEE: So you're going to analyze the existing experiments in some way.

MR. KEE: Well, in effect, I mean, we're

using RELAP5 to do a lot of those results that were on that slide --

CHAIRMAN BANERJEE: Right, sure.

MR. KEE: -- came out of an application that's been benchmarked against a lot of data.

CHAIRMAN BANERJEE: Well, we'll look at that. Let's not worry about that right now.

MR. KEE: So I just wanted to point, so the only thing here that's maybe of any interest to the Committee so we can move along quickly is I mentioned that there's this gap at the bottom.

So the water, of course, it comes in from the injection, and we're talking about a cold leg break here, comes into the downcomer, but then it just runs right back out the break because there's nothing to stop it. I mean, it just goes around and runs out the break.

And so, but there's plenty sufficient flow to keep this downcomer basically full of water. But the driving head is whatever you can get between the, say collapsed level in the core and the cold leg. That's what's pushing the water in.

So we have that difference, and what we were trying to talk about was well, if you have 7-1/2 grams on this fuel for a fuel assembly, 7-1/2 grams for fuel assembly, so whatever that is times 195 times 7-1/2, that's all here on this fuel, and I already mentioned that the fuel sits up on stands on feet, sets up off this bottom plate, and there's a lot of big holes in this bottom plate.

That, there's this huge opportunity for this water to also come around, and this is dilute water, by the way, to come around into these holes that are provided at several elevations we've mentioned.

And that, because the pressure at the top is roughly the same, these two columns see roughly the same pressure, then there's a tendency to equalize. It won't totally equalize, but there's a tendency for those levels to equalize. And so that was the path that I was alluding to earlier.

DR. WALLIS: And what if you go up to the top and spill over the top?

MR. KEE: And it can spill over the top, and it can do that, but these holes are of much more advantage. That's why they're there.

CHAIRMAN BANERJEE: So we are going to look at that bottom geometry later on.

MR. KEE: We're going to try to get drawings of that. I've asked for that.

CHAIRMAN BANERJEE: And we won't quiz you too much about the size of the holes.

MEMBER CORRADINI: But can I just summarize since we have a cartoon? So just so I'm clear, so for the cold leg, because it bypasses, the only way, and because the flow and the relative sizing and such, the holes, whatever, I can't remember what you call them, but the holes that essentially allow flow up into the upper head, are really operative under the cold leg break.

And if the bypass is not blocked, I can essentially get flow out and around through those other --

(Simultaneous speaking)

MEMBER CORRADINI: Side holes. I can't remember what you called them either.

MR. KEE: So Rodolfo mentioned that at certain break sizes, there's actually, I show a gap here, you know, that it kind of runs down. But it can be at certain break sizes excessive enough that it comes up and over.

DR. WALLIS: So Ernie, are you saying even if the core gets completely blocked at the bottom, this cools that? Is that what you're saying?

MR. KEE: I don't see how it could not be cooled --

DR. WALLIS: Was that your case? Are you just going to forget about --

MR. KEE: No, we completely blocked it off totally. This path is blocked. When we did these ones, cases that Rodolfo was referring to, we had it completely and totally blocked. This path is blocked and the core is blocked off.

(Simultaneous speaking)

DR. WALLIS: It's a very different phenomenon blocking the bypass, isn't it?

MR. KEE: It is, indeed. There's much larger holes and gaps. There's a 2 inch gap --

CHAIRMAN BANERJEE: How big is that gap there?

DR. WALLIS: So you need to do tests or something.

CHAIRMAN BANERJEE: What's the annulus there? How big is the annulus?

MR. KEE: Baffle to barrel, so the core barrel sits around --

CHAIRMAN BANERJEE: Yes, that's annular gap.

MR. KEE: Well, the fuel assemblies are roughly 8 inches square. I wish we had that picture. But the flat, one of the flats is seven fuel assemblies. The core is 15 wide, so there's big gaps in between. Now I have, I should --

CHAIRMAN BANERJEE: I think, what are you showing us? That's all the fuel assemblies as surrounded by sort of a shroud?

MEMBER CORRADINI: Yes, but it's asymmetric, because it's like this. Certain areas are fat, certain areas are thin.

MR. KEE: You would like to have a perfect cylinder, well you would probably really want to have a sphere, but for neutron conservation, right? But they can't do that because the fuel assemblies are square.

So you have seven on a flat, then you cut it, then you set them in so there's kind of corners. And then there's seven more flat, and then there's some corners, jaggedy corners. Well, the thing that holds those fuel assemblies in the orientation of them like this is called the baffles, the core baffle or core former.

And what I was about to mention is there are plates out here. Obviously this can't just sit in the air. So there's plates that hold those baffles, formers in and locate them. They sit like this, and they also have big holes in them. We can find that, too.

DR. WALLIS: The point here is I don't understand is even if you have 15, suppose you have 20 grams per fuel element, you block everything, then the water will go this way.

MR. KEE: Yes. It's either over there or on the core. So it's --

DR. WALLIS: So what do you have to do to convince us that this will work?

MR. KEE: Well, that's the thing we avoided is a lot of detailed analysis. Now again, we would --

DR. WALLIS: Why bring it up if it's irrelevant? I mean, are they going to show it cures the problem, or --

MEMBER CORRADINI: I think all they're saying is that they ignored a realistic effect that they've yet to analyze.

MR. KEE: That's what I'm --

MEMBER CORRADINI: That's all he's saying.

DR. WALLIS: But this would mean we didn't have to worry about 15 or 7-1/2 or 5 grams or whatever it is.

MEMBER CORRADINI: For their plant.

DR. WALLIS: Yes, for their plant.

MR. KEE: Yes, we kind of made that point in the responses. But you may start asking me a lot of questions about everything that happens in here, and then we'll have, you know, that discussion.

DR. WALLIS: Do you propose to do that?

DR. JOHNSON: So Ernie, I think we can characterize it as an insight to defense in depth there.

MR. KEE: That's the way we take it right now.

CHAIRMAN BANERJEE: Let's look at this a little bit more. Presumably because this is a cold leg break, the 15 grams that the staff said is for a hot leg break where the flow is quite a bit higher. Right?

So for a cold leg break, about 60 percent of the flow goes out of the break or 50 percent or some number, I don't know what it is. And clearly, the velocities are much lower and different amounts of debris are limiting. That 15 gram is really for a hot leg break.

MR. KEE: Yes. Yes, it is.

CHAIRMAN BANERJEE: That's where it comes from.

MR. KEE: Yes, okay.

CHAIRMAN BANERJEE: So the cold leg break has a completely different limit because it's not limiting, that's not what we have in the approved SE. That 15 grams is for a hot leg break. Staff can correct me, but that's really what it is, right?

Now for a cold leg break it's some lower number. I don't know what it is, but we never really examined that because that wasn't limiting. Now what we are now looking at is what would be, in this case, what will happen in a cold leg break.

So some portion of the flow goes out from your break, some portion goes in, carries with it your debris. Some of the debris which tries to go through the core from the bottom gets blocked. Some of the debris can come in from the sides with the flow.

And then what happens to that? Does it block it from the sides or what happens because the debris has to go somewhere. That's the whole new issue because now you've got debris coming in and blocking the fuel from the sides.

What happens to the middle of the fuel? Do you get a layer of stuff forming on the sides? I mean, it's a whole different problem you're trying to deal with here. And it brings up a whole different set of issues, right?

MEMBER CORRADINI: Change reality's ugly.

CHAIRMAN BANERJEE: I don't know what it is, I mean, you haven't done any experiments.

(Simultaneous speaking)

CHAIRMAN BANERJEE: I mean, if you want to say if this you have to do some experiments and show us what is happening, that is it.

MEMBER CORRADINI: Because you'd get --

CHAIRMAN BANERJEE: You'd get stuff on the sides.

MEMBER CORRADINI: You'd get accumulation all over the place.

CHAIRMAN BANERJEE: All over, yes. I don't know what will happen, if that happens. I mean, an experiment might show that yes, you've got paths in, who knows.

MEMBER CORRADINI: I personally have a hard time figuring out how it would be worse, but it would sure be complicated.

CHAIRMAN BANERJEE: Probably not worse, may not be better. But we don't know.

MEMBER CORRADINI: It would be complicated.

MEMBER CORRADINI: Yes, it would be complicated. But that's why I asked did you do some new experiments to show that this path for in-vessel effects was an appropriate, you know.

DR. LETELLIER: If I might ask, do you have specific phenomena or interactions of debris with the fuel that you're concerned about specifically?

CHAIRMAN BANERJEE: Well generally, the flow brings debris in, right? So if the flow is coming through holes on the sides or holes at the bottom, still bring debris in.

And that debris is depositing. In the other case, it's depositing as the flow goes up. Here, as the flow goes crosswise. I mean, I don't know --

DR. LETELLIER: By assumption, we had assumed that there is enough debris deposited to block the flow. You can't block more than 100 percent of the flow. So we were only concerned about --

(Simultaneous speaking)

CHAIRMAN BANERJEE: Not sideways, right?

DR. LETELLIER: -- thereafter.

CHAIRMAN BANERJEE: Or did you assume that it would block it sideways, as well?

DR. LETELLIER: No.

MEMBER STETKAR: We didn't credit it.

MEMBER CORRADINI: The holes aren't there in their analysis.

CHAIRMAN BANERJEE: Oh, you --

MEMBER CORRADINI: The holes aren't there in their analysis. It doesn't exist.

CHAIRMAN BANERJEE: I thought the RELAP analysis --

MEMBER CORRADINI: The four little, I just want to make sure what we're doing. We're talking about the three little holes on the side that you guys ignore totally.

MR. KEE: Yes, the other holes we're talking about later are here.

MEMBER CORRADINI: Up there.

CHAIRMAN BANERJEE: Okay, so those holes on the side were never taken account of then?

MEMBER CORRADINI: Right.

MR. KEE: No, sir.

CHAIRMAN BANERJEE: So this picture doesn't enter into any of your analysis, not even into the RELAP 5?

MR. KEE: No, only in a qualitative way. Only qualitatively.

MEMBER CORRADINI: They've just recognized that mean. I'm just recognizing the fact that --

MEMBER RAY: I heard the term defense in depth, and honest to Pete, I have no idea what you're talking about.

MR. KEE: So the point being that if 7-1/2 grams are on the fuel, then there's none anywhere else because it's all on the fuel. And it's no way would these paths, which do exist in real life, be blocked. They just wouldn't be.

CHAIRMAN BANERJEE: Well no, there's stuff coming in all the time, right?

MR. KEE: Yes.

CHAIRMAN BANERJEE: So imagine that the liquid has a certain amount of debris entrained in it. So yes, what it does, it first comes and blocks, it tries to go first which is in through the fuel, the lowest resistance flow path.

It blocks that, so the full bypasses goes to the next lowest resistance, and debris starts to go there. And then debris progressively goes until it gets, that's what happens when you see an experiment, right?

MR. KEE: Sure.

CHAIRMAN BANERJEE: You see an experiment, it goes initially wherever the flow is highest, it blocks it. And then it slowly moves around until it blocks everything. I mean, that's really what happens.

MR. KEE: We agree.

CHAIRMAN BANERJEE: You know, so I mean --

DR. LETELLIER: Can you imagine those horizontal holds are progressively blocked --

CHAIRMAN BANERJEE: Not the holes. The fuel. It goes through the holes into the fuel, and then the question is what happens in the fuel now because you've got all these fuel rods. It's a forest of rods, right? And that forest of rods, I don't know, until you do an experiment where that starts to block.

So it's just another path, but there's a whole set of spaces there so it tries to go. And then it gets stuck in the spaces, and then it goes to the next one. And it just goes on and on and on. It's very boring, but I think that's really what unfortunately this stuff, you know, when I went and saw an experiment once, it's surprising.

The first time we saw this was in Erlangen where we saw these little fibers, and we thought it would be impossible for that to block the core. And sure enough, it completely formed a mat on this stupid spaces.

MR. KEE: Sure.

CHAIRMAN BANERJEE: I mean, minute amounts.

MR. KEE: Sure.

CHAIRMAN BANERJEE: It is amazing what it did, and horrible. So --

MR. KEE: Yes, so you're right. But at 7-1/2 grams for fuel assembly, again, is where we call failure.

CHAIRMAN BANERJEE: Okay.

MR. KEE: So more and more and more can come in --

(Simultaneous speaking)

CHAIRMAN BANERJEE: So this doesn't effect us in any way, what you're showing us. It's of no importance to us, we should just ignore this.

MR. KEE: Yes.

CHAIRMAN BANERJEE: What is important is the holes at the top, right? That we shouldn't ignore.

MR. KEE: That's right. We take credit for those.

DR. LETELLIER: I had mentioned this morning that if we did reduce that threshold to 5 grams for a cold leg break, it would increase our risk to a factor of five or six.

CHAIRMAN BANERJEE: That's fine.

DR. LETELLIER: So we're aware of the implications. We've tried to understand the uncertainty in these parameters.

CHAIRMAN BANERJEE: But we would be interested in the holes on the top because that's a vital mechanism which could be operational. And it actually gets rid of your hot leg breaks, right?

DR. WALLIS: First, 15 grams is something like 3 pounds over the whole bottom as far as I can work it out. It's 1-1/2 kilograms or something. So 3 pounds of fiberglass, how many pounds of other material do you have? Silting, particles, concrete, how many pounds of that do you have?

MR. KEE: Yes. So this number, I just got to keep repeating this because it's important to understand --

DR. WALLIS: How many pounds of other stuff here?

MR. KEE: -- that 15 grams for fuel assembly includes a lot of other stuff. It includes chemicals that we don't have, it includes particulate that probably can't get through the strainer.

DR. WALLIS: That's 3 pounds. I've heard about hundreds of pounds of sand or something. Is that not true?

DR. LETELLIER: We'll look at examples of what's the debris types are in the pool.

DR. WALLIS: Just tell me now. It's a lot more than 3 pounds.

DR. LETELLIER: But remember, the test condition, the --

(Simultaneous speaking)

MEMBER STETKAR: They're fuel assemblies.

DR. LETELLIER: -- was established under conditions that included representative particulate --

DR. WALLIS: I don't believe it.

MR. KEE: No, no --

DR. WALLIS: Well, I don't.

MR. KEE: Are we talking about fuel --

(Off record comments)

MR. KEE: Yes, I mean, that used basically a design basis --

DR. WALLIS: Downstream tests for the valves on the piping and so on used enormous amount of debris compared with used in the tests for the fuel assembly. I could never understand why they were so different.

CHAIRMAN BANERJEE: Well, I think from the presentation here, you just had these two slides for the in-vessel?

MR. KEE: Yes. So we're done?

CHAIRMAN BANERJEE: So why don't we take a break now, and then we come back and we go on to doing chemical effects and the other things that you've done experiments on, that we see what new experimental data you have. Okay? So we take a break for 15, well, let's come back at 3:15. Thanks.

(Whereupon, the above-entitled matter went off the record at 3:02 p.m. and resumed at 3:27 p.m.)

CHAIRMAN BANERJEE: So we are going to go back in session and I'm going to turn it back to Mike Murray to, I guess, deal with chemical effects next.

MR. MURRAY: That's correct, we'll go in and Kerry Howe will lead us in discussion on chemical effects.

CHAIRMAN BANERJEE: Just, Mike, to get our time organized and, I would like everybody to try to do this as well, we'd like to go through chemical effects and head loss so that we have a 4:15 sort of, 45 minutes to do that so that we can get to the specific examples.

And then, right at the end of 15 minutes or so, we close the session so we can discuss some of the material that you can show us. The flow paths and the holes and all these things. Okay? Does that work?

MR. MURRAY: That will work.

CHAIRMAN BANERJEE: All right, let's do that then.

DR. HOWE: Ready then?

CHAIRMAN BANERJEE: Ready.

DR. HOWE: Okay, my name is Kerry Howe, I'm from the University of New Mexico and I will try to make the chemical effects brief.

And as Dr. Wallis mentioned, I think it's good to start with the overall perspective. And so to try to tell you where I'm headed with this I just got a few slides here.

I'm going to talk about the experimental setup that we did first, the experiments that we ran from a chemical effects point of view, and then a brief summary of the results we got from it. But the key to all of this is how chemical effects was really implemented in the CASA Grande.

The short story is, from an experimental point of view we did not have significant chemical effects and then that lead to a way necessary to account for the uncertainty in that results and including chemical effects in CASA Grande.

So this is a, on the right side, a picture of the experimental setup. And the goal here was to do a physical testing that was representative of the chemical munitions at South Texas with a goal of looking at the progression of chemical effects starting from the corrosion processes, constituents getting into solution, precipitation happening and then that precipitation causing potentially a head loss problem.

Some of you might recognize the tank there, that tank was used in the ICET testing back in 2005 and 2006. Back in the days when we were specifically focused on the corrosion part of the equation.

So we're using that existing corrosion tank. And then on the right side of that picture we've added three vertical head loss loops.

The purpose of the loops was to add in the head loss component to the testing. The fact that there's three vertical loops there was to get a sense of the fact that there is variability in head loss and to essentially be able to conduct parallel tests and have some measure of the variability that occurs there.

The testing was a 30 day corrosion test integrated with both corrosion and head loss, as I mentioned. We tried to make this as realistic and prototypical of South Texas as possible so we used a prototypical temperature profile, we did a medium break LOCA and a large break LOCA and those temperature profiles were generated by Texas A&M.

We used prototypical materials, chemicals, flow rates through the debris beds, the pH solution. In some of their other testing we explored two different types of debris beds, and we've talked about some of this earlier.

The blender debris bed and also the NEI formulation, which is a pressure wash approach. The debris bed shown in the lower right corner is 18 grams of fiber using the NEI pressure washing method.

And as you can see, that's about two and half or three inch of debris in a six column. The other picture there is the corrosion materials that we would use.

CHAIRMAN BANERJEE: So these beds were pre-formed?

DR. HOWE: Yes. So the progression of the test, what we would do is we would pre-form the beds in the debris in those three columns. So the columns are essentially isolated from the tank.

We would prepare all the debris, put them into the columns and make sure we had a stable consistent head loss before the beginning of the test. And then the tank was heated up to the temperature.

We started at 85 degrees C. We would then put the corrosion materials in the tank and as soon as the corrosion materials were in the tank we would open valves and link the tank to the columns. And that would be the initiation of the test.

CHAIRMAN BANERJEE: What's the buffer used in the plant?

DR. HOWE: So in South Texas it's trisodium phosphate. And for those of you who do remember the ICET test, we did look at five different types of plants with different insulation materials and different buffers.

The test that was most similar to South

Texas, which is a high fiber plant with TSP as the buffer, was the ICET test that really had the least chemical effects. There was really nothing that happened in that test. The least interesting of the five.

I mean, so our expectation coming into this test was that there is certainly the opportunity that we would not see chemical effects with this combination of materials and buffers.

And that is indeed what I'm showing on this slide and the results that we did see in these two tests that we did run.

CHAIRMAN BANERJEE: Is there an attempt to reduce the aluminum exposure in the plant?

DR. HOWE: There has been some movement of where, I'll let Ernie answer that question.

MR. KEE: No, we still store the scaffolding where it was. Now I do believe though in the ICET series that there was more, and Nate correct me if I'm wrong, but I believe there was more aluminum assumed than what was in the plant.

And there were other materials we have removed for like Cal-Sil, some of the bad insulation. Now is that, did I saw that correctly? I recall that we have the extra aluminum in --

DR. HOWE: You said the ICET test, the ICET test did have more aluminum than South Texas has. The test that I'm describing here --

CHAIRMAN BANERJEE: Right amount.

DR. HOWE: -- has the right amount. Yes. In these tests we measured constituents and solution like aluminum and calcium and silicon.

Overall, in the two tests, the concentrations of those materials were low. I'm showing here the aluminum was less than a milligram per liter. That's significant because it's below what the predicted solubility of aluminum hydroxide would be.

And so it's also less than the concentration that would be predicted to end up in solution using the WCAP calculator that predicts aluminum concentrations.

We did reach a steady state concentration in just a couple days. So it grows to that concentration and stayed the same for the next 30 days.

We used turbidity as a measure of evidence of precipitation and solution. So turbidity is a measure of the cloudiness of the water if we have a precipitate forming in solution.

And circulating with the solution we would see that as an increase in cloudiness. And we did not see that so the fact that turbidity was not rising is an indication that we had no precipitation forming in solution. In the --

DR. WALLIS: Doesn't precipitation occur because of cooling? Isn't that the only, why would it occur otherwise?

DR. HOWE: So in this test we used a prototypical temperature profile where we started at a high temperature and we did --

DR. WALLIS: Did cool it and then --

DR. HOWE: We did cool it overtime. So the beginning temperature in these tests was about 85 degrees C, 185 degrees Fahrenheit. And we cooled it down to just under 40 degrees C, which is right around a 100, right around a 100 degrees Fahrenheit.

So, and with that cooling, and you're right, Dr. Wallis, as the water cools we do have a decrease in the solubility and that would be an indication, that would be one of the things that would cause precipitation --

DR. WALLIS: Never reached the limit.

DR. HOWE: -- and we did not reach that

limit in these tests. Coupled with that we had no increase in the head loss during the medium break LOCA tests.

In the large break test we did have additional materials in the tank. We had some zinc galvanized surfaces in the tank that were not present in the medium break LOCA.

We did see an initial spike in turbidity in that test. Which as a result of other tests we've done, we attributed that to a, essentially a release of material from the zinc surfaces.

So in essence we can think of it as a cleaning of preexisting scale off of the surface and essentially a source of particulate material into the solution. And we did see a small increase in head loss during that test, but it was literally just a few inches of water column.

So the overall result of these tests is that we did not see a significant impact of chemical effects. So then that leads us to, how do we use those results in this license submittal?

There is certainly some uncertainty. We can't stand here and say we could guarantee there will never be any chemical effects. So we wanted to incorporate uncertainty in that result in CASA Grande.

And so the way that was done, and Bruce is going to go into a lot more detail on the actual numbers and procedures of how it's done, but basically what we did is included head loss from chemicals as a multiplier on the conventional head loss.

So there was a calculation for conventional head loss and then if certain conditions were meet, that value was multiplied to give an additional head loss from chemicals. The multiplier was based on probability distribution functions and there were different --

DR. WALLIS: I don't understand why it's a multiplier. It depends on where the chemicals are. In the LANL test the chemicals are on the top.

DR. HOWE: Yes. And then there would be additives.

DR. WALLIS: So it still doesn't matter how much fiberglass you had, if it's a layer on top. It's as an addition, it's not a multiplier.

DR. HOWE: That's true. So there is a, there was some discussion on whether it should be a multiplier or an additive effect, and that was, I think, the subject of an RAI. And again, Bruce will talk a little, a lot more detail about how that approach worked.

The other thing that we wanted to do since we essentially had a no result in our prototypical test, we also wanted to explore a little bit how far we were from a boundary where precipitation might actually occur.

So if it didn't occur under prototypical South Texas conditions or at least the tests that we ran, the question would be, are we a small distance away from the actually conditions or a large way? So what we did, we've also did some additional testing where we essentially tried to push the limit and see where chemical effects may occur.

So we, there's tests that are described as T3 and T4. They were called overloaded tests here.

What we did is we ran for a higher temperature for a longer period of time. In essence what we did was hold a temperature of 85 degrees C for five days and then ramped the temperature down over an additional five days.

So we held it for a period of time to try to encourage corrosion and then dropped the temperature to try to encourage precipitation.

And we did that with a larger amount of aluminum in the tank than what would be representative of South Texas. It was almost a hundred times more surface area per unit volume in this test, in these test, than what would be representative in South Texas.

And when we did do that we were able to cause enough corrosion so that when we dropped the temperature in the second five day period we actually did cause precipitation to happen.

And what that did is it gave us a good understanding of where our limits are, how much aluminum actually is released under conditions. And what we did find is when TSP isn't present, there really is less aluminum corrosion than what the WCAP formulation predicts.

So what essential we, with this and with some other experiments, we've been able to identify that there is a passivation effect between the phosphate and solution and the aluminum surfaces where after a day or so there actually is no more release of aluminum and solution.

We're also able to find that that precipitation in our tests, as we were dropping the temperature, did occur in a range that was consistent with thermal dynamic modeling. And also consistent with a lot of testing that was done at Argonne National Labs. There --

CHAIRMAN BANERJEE: How long is the TSP effect? I mean if, because after all TSP will dissolve over a period of time and may or may not get to the aluminum. So is it significant, the TSP passivation?

DR. HOWE: The effect is significant. So the effect, once the TSP dissolves and the phosphate is in the solution, that phosphate then is, in essence, acts as the corrosion inhibitor.

CHAIRMAN BANERJEE: So it does, does it stop off, does it shutoff the corrosion entirely or does it allow corrosion to continue?

DR. HOWE: Well we found is that the corrosion, under the conditions we were testing, the corrosion stopped entirely.

CHAIRMAN BANERJEE: The --

DR. HOWE: Now a --

CHAIRMAN BANERJEE: -- corrosion that you see is just in the period before the TSP dissolved?

DR. HOWE: No, I'm sorry. So it doesn't happen instantaneously. So it does cause --

CHAIRMAN BANERJEE: It doesn't happen

passively.

DR. HOWE: -- passivation effect, but it takes one to two days for that inhibition layer to have formed on the aluminum surface. So there is some release of aluminum during the first one to two days.

CHAIRMAN BANERJEE: So how long do you take to dissolve the TSP or --

DR. HOWE: The TSP dissolves quite rapidly. Within the first hour and a half of an event.

CHAIRMAN BANERJEE: Well you just, this is your experiment, right?

DR. HOWE: What?

CHAIRMAN BANERJEE: This is your experiment?

DR. HOWE: Yes.

CHAIRMAN BANERJEE: You expose the TSP basket or whatever, so --

DR. HOWE: Well in our experiment, so in these particular overloaded tests, those were done, the TSP was added right away. Because we were specifically looking for the effect of the TSP under these conditions.

In our prototypical test, what we did is we took the appropriate amount of TSP. We did not add it in a dry form in a basket in the tank, but what we did is we tucked it in a container off to the side.

We pre-dissolved the TSP. And then using a metering pump we pumped it into the tank over, starting at 15 minutes into the test and ending at 85 minutes into the test which would represent the amount of time it would take to dissolve.

CHAIRMAN BANERJEE: Could TSP in the plant just be put in a float box so it dissolves?

MR. KEE: Yes, sir.

DR. HOWE: Ernie mentioned that there's the bioshield wall and there's large holes between the bioshield wall and the outer annulus and the TSP baskets are positioned just outside those holes. So as water is coming through the bio, am I correct here?

MR. KEE: Yes, it runs through.

DR. HOWE: As the water is coming through the bioshield wall it's going to run into those baskets.

MR. KEE: Yes, and there's some located inside the wall and some outside the wall. The ones outside the wall are by those holes.

CHAIRMAN BANERJEE: Go ahead. That's it?

DR. HOWE: So the, yes, and we're trying to keep it quick, aren't we? So the overall result is, I think we are able to validate previous existing information on solubility.

We are able to demonstrate, by using these overloaded tests, we essentially found the boundaries of where we would have precipitation problems. And by doing that we're able to demonstrate that we really didn't have precipitation problems in the earlier medium break and the prototypical tests that we had done.

So we feel there's a bit of a safety margin there. And as Bruce is going to talk about here in a minute, because we can't be a hundred percent certain about that, there is still a factor of chemical effects being included in CASA to account for uncertainty.

CHAIRMAN BANERJEE: Okay, thank you.

DR. HOWE: Was that the record for how fast we got through --

CHAIRMAN BANERJEE: That's great. I mean you got a lot of brownie points for that. Good job.

MR. MURRAY: So kind of get the stage set for somewhat, the next slide show starts at 66 and we get to the examples at 91. So we got a ways to go, so.

DR. LETELLIER: And with that in mind let me explain the format of this topic and then describe some optional material that we could choice to differ. Mr. Chairman, you hope to finish this open session by 5:30, is that correct?

(Simultaneous speaking)

DR. LETELLIER: In the example in front of us.

CHAIRMAN BANERJEE: Yes.

DR. HOWE: Scenarios.

DR. LETELLIER: Okay, I think we do have time.

DR. HOWE: Okay.

DR. LETELLIER: So in this part of, this topic in general discusses head loss models that are implemented in the analysis. And it's presented in two parts.

We chose to talk about chemical head loss first because it's a natural segue from what Kerry described. But please remember what he explained that the chemical head loss is implemented as a multiplicative factor on top of a conventional head loss estimate. And so it's a little bit out of order in that respect.

Each section is discussed first and the primary objective is so that you understand what's been done in the STP LAR.

CHAIRMAN BANERJEE: So let me understand this. Experiments often show that, you know, with pure fiber or something or fiber plus particles you have a certain level and then you add chemicals and you get a bump up. Is multiplicative, why did you choose to go that way rather than an additional head loss to do the chemicals?

DR. LETELLIER: I'm not sure if I have a good response, a satisfactory response, however we do recognize the value of an additive type of model. It was raised by the staff in our RAI process.

As we've gone to some trouble to separate our multiplicative result into an additive component with a little bit better information for calibrating the response per unit quantity.

CHAIRMAN BANERJEE: Does it amount to more or less the same thing at the end or is there a significant difference?

DR. LETELLIER: We actually, at the moment we don't have an independent additive model so the results are in fact identical. But we're exploring the benefits of separating it into an additive component.

CHAIRMAN BANERJEE: Okay.

DR. LETELLIER: Our, I think it's fair to admit that this has been a process of continuous improvement. So in the beginning we had a small number of thermal hydraulic calculations.

We started our quantification in the beginning. We had limited test data and we applied a multiplicative factor.

Throughout the past two and a half years we've tried to take advantage of those improvements that have a definite positive impact, a beneficial impact, on our analysis. This is one that we may revisit.

DR. WALLIS: Because your inflation factors are enormous?

DR. LETELLIER: They are.

DR. WALLIS: Twenty-four, something like that.

DR. LETELLIER: Considering we haven't seen any chemical --

DR. WALLIS: And yet we just heard there aren't any effects.

DR. LETELLIER: That's true.

DR. WALLIS: So which way you going to head? Are you going to multiple by 24 or by one?

DR. LETELLIER: Let me show the example and then we can discuss that.

DR. WALLIS: Yes.

DR. LETELLIER: My intent is that we understand what's in the LAR and then, at your option, we can look at additional, supplementary information that helps us calibrate the degree of uncertainty inherent to our approach.

So let's look at chemical head loss first. We've discuss a couple times if there are two criteria involved that must be satisfied before we adopt or apply any chemical effect.

First the chemical product is assumed to form only after the temperature falls below a 140 degrees nominally. This is one of our uncertain parameters. I don't know exactly what that precipitation temperature is so there's a normal distribution in the standard deviation of plus or minus five.

Because we're basing all of our calculations on two representative temperature histories, those times are five hours for a large break LOCA and 16 hours for small and medium break LOCAs. That helps you judge the point at which we introduce chemical effects respective to the switch over times.

DR. WALLIS: Are you talking about your screens or the downstream effects on the core?

DR. LETELLIER: So at the moment we --

MR. KEE: The answer is yes.

DR. LETELLIER: Yes, the answer is yes. At the moment we're talking specifically about an increase in the head loss of the strainer.

DR. WALLIS: But you never get such a thin, well I guess you would. You might possible get such a thin layer on the strainer with a very small break, not far from insulation.

DR. HOWE: You might.

DR. LETELLIER: In fact there is a transition in break size where those beds begin, become contiguous. And that's the second criteria in fact.

We only apply the head loss, chemical head loss factor if we have an equivalent 1/16 inch bed thickness that's present --

DR. WALLIS: Is that just a guess or is that based on the tests?

DR. LETELLIER: As I said, it's difficult to form a contiguous bed even in a vertical column with such a small quantity. So if you have, Janet, do you have anything to add about test experience?

I think in the strainer configurations it's extremely difficult to form a bed with the crenelated designs.

It's a decision point that we've investigated parametrically and found that it's not very sensitive to that choice. We could apply these factors at times zero with no bed and it won't change our risk substantially.

DR. WALLIS: It seems funny because in fact that's when you need it the least. I mean you need it when you got a thick bed and you're going to apply a big factor.

You got a huge tank for a very thin bed you apply the big factor, you still wouldn't bump it up very much. So why do you care about this cutoff?

DR. LETELLIER: That's been noted actually by the staff. In some cases a thin bed condition can lead to higher head losses than a thick bed.

So we have a little bit of work to do with respect to the correlation in these factors. And I think through the RAI response we've been able to identify the magnitude of the required effects.

Here's an example of the mysterious head loss and chemical head loss factor. I'll start from the bottom up.

First of all this probability distribution does not represent a correlation to data, it's designed to preserve the attributes of the test information that we do have available.

So in prototypical strainer testing for large break loadings, we have seen factors as high as 2.25. Roughly a factor of two times higher than the conventional debris alone.

And we started with that at the baseline and we applied this factor to the small breaks, slightly higher factor to the medium breaks and the maximum factor of three to the large breaks. That's the average.

On top of that we considered the tails of this distribution and we introduced factors that were high enough to introduce a significant failures caused by chemical effects. Even though we have not seen the presence of severe chemical effects in prototypical --

DR. WALLIS: So how do you get these effects in the test? Do you use the owner's group type of chemical?

DR. LETELLIER: Yes. The WCAP surrogates. That's correct.

The implementation requires a little bit of mechanics. First of all you don't want this to be less than one or else chemicals will be a benefit. So we shift the distribution, shift the mean by the unit.

And we're also exercising a stratified sampling strategy here so that we can emphasis those higher values without bias. Bias end results.

MEMBER CORRADINI: I have questions. Yes, I'm confused. So what you're telling me is you made sure that you preserved the observables, but everything about that is there but not sampled?

DR. LETELLIER: No, we are sampling the continuum for any individual event.

MEMBER CORRADINI: Okay, but, I mean to Graham's point, the right hand side of the X-axis is unphysical.

DR. LETELLIER: In some --

MEMBER CORRADINI: Am I missing something?

DR. LETELLIER: In some respects that's true, except we do have some conditions with thin bed loadings where the addition of a small amount of chemicals actually has a severe effect.

MEMBER CORRADINI: Oh.

DR. LETELLIER: But remember, it's a

presumed addition of chemicals. So that's the only disconnect that I can point to.

We want to accommodate the potential effect of chemistry without unduly biasing our results.

DR. WALLIS: Well what matters is whether the chemicals get trapped in the bed.

DR. LETELLIER: That's right.

DR. WALLIS: And if you have a thin bed and the, the thinner the bed the bigger the effect because they got more, the ability to fill it up.

DR. LETELLIER: That's correct.

DR. WALLIS: And they don't feel it up unless you've already got particles in the bed to catch the chemicals. So everything's interrelated.

DR. LETELLIER: That's true.

DR. WALLIS: Yes.

DR. LETELLIER: That's the purpose of the tail is actually --

DR. WALLIS: Does this take account of the particles in the bed as well?

DR. LETELLIER: The prototypical testing actually did include the particulate.

DR. WALLIS: Yes.

DR. LETELLIER: And I think everyone

understands, but perhaps not, that the prototypical strainer performance tests are done with very challenging chemical product loads. Thirty days of continuous spray operation.

For example, if we get into this additional detail, the South Texas strainers were performed with over 1,900 pounds equivalent. So in the containment you would perhaps produce 1,900 pounds of chemical product.

And that's the concentration that was introduced to the flume tests in proportion to volume. That's a lot of chemical product.

DR. WALLIS: Do they all go through to the core?

DR. LETELLIER: Some of them do.

DR. WALLIS: 1,900 pounds of chemicals or three pounds on the core are fibrous, doesn't sound good at all.

DR. LETELLIER: Well --

DR. WALLIS: If they get trapped.

DR. LETELLIER: I'm trying to emphasis that we don't see chemical formation.

DR. WALLIS: No.

DR. LETELLIER: But it's incorporated in

our estimates of failure mode.

CHAIRMAN BANERJEE: You don't see chemical precipitates.

DR. LETELLIER: That's right.

CHAIRMAN BANERJEE: You see, the chemicals are the solution.

DR. LETELLIER: And it's not fair to say no chemical effects, we carry, itemize some effects that were observed. I'm seeing corrosion.

We do not see a crisis precipitation. In fact, like had been observed in the ICET tests for some combinations. And we've actually conducted 30 day tests looking at an entire history.

DR. WALLIS: So, Bruce, can I go back to that point, you said 1,900 pounds of chemicals and some sort of hypothesized terrible case. Do they all go through to the core or do they get taken out in the strainer or how do you know?

DR. LETELLIER: The chemicals continue to circulate. There's a measurable head loss effect indicating that some amount is filtered. But nonetheless, the solution remains cloudy and you --

DR. WALLIS: So you should do your end core, your core assembly tests with huge amounts of chemicals like this?

DR. LETELLIER: Go ahead.

DR. LEAVITT: And one, no. Keep in mind what Kerry said. At UNM we didn't see, under prototypical conditions we wouldn't expect the chemicals.

And so STPs test was set in the deterministic framework of the sprays on for 30 days and the non-optimal or very conservative temperature profile, higher pH. So their chemical inventory that they tested with was highly improbable, if that's the right word.

So if, we should test with realistic amounts of chemicals. So remember the WCAP calculator doesn't take into account the passivation effects of aluminum corrosion.

So not only were the conditions under which the inventory was generated very conservative, we ignored the possible or the observed effects of passivation. So we would have even much, much less than we actually tested with.

DR. LETELLIER: As Janet said, those conditions are highly improbable, but our challenge is quantifying that probability. We don't have an infinite amount of test data under all conditions, so this is the approach we've adopted to accommodate that potential.

DR. WALLIS: So you assume those 1,900 pounds go through to the core might deposit on the core?

DR. LEAVITT: No.

DR. LETELLIER: The presence of chemicals in the core is captured in our 7.5 gram limit, which we believe includes particulates and chemicals.

MR. KEE: It does.

CHAIRMAN BANERJEE: So the, if by some mischance you didn't get TSP dissolved, if there was some probability of that happening, what would happen? Would you get quite a bit more aluminum hydroxide in the solution?

DR. LETELLIER: You would experience more aluminum corrosion than we observed in the CHLE testing. However, you would be back in the regime of the WCAP performance test, which is supposed to maximize the inventory by design.

MR. KEE: Right.

MEMBER SCHULTZ: Have you done model sensitivity evaluations, different types of modeling of this approach so that you can identify the impact on the overall results?

MR. KEE: I think we need to be careful because in the absence of the buffer, the buffer is there to neutralize the solution.

MEMBER SCHULTZ: Sure.

MR. KEE: So boric acid is acid, so without any buffer I think it would accelerate corrosion process is quite --

CHAIRMAN BANERJEE: Well on the zinc particularly.

MR. KEE: Yes. Anything that gets exposed to it, yes.

DR. LETELLIER: I'm sorry, were you referring to modeling of the chemical environment or --

MEMBER SCHULTZ: Yes.

DR. LETELLIER: -- to the statistics?

MEMBER SCHULTZ: Well some of both. It seems like you're trying to, because there's some unknowns, you're assuming what, the way you describe it, the worst of the worst. You have to --

DR. LETELLIER: Right. So all of --

MEMBER SCHULTZ: So looking at your distribution, for example, then also you got the WCAP results that you're comparing to the physical phenomena that you've seen in representations of the facility. So --

DR. LETELLIER: Maybe Janet can describe some --

MEMBER SCHULTZ: It seems like you'd like to take a different approach and just see what impact it has on the overall result.

DR. LEAVITT: Well we did do an evaluation such as that. So it wasn't an intense statistical analysis evaluation --

MEMBER SCHULTZ: Okay.

DR. LEAVITT: -- but what we did is we looked at the, even using the WCAP calculator and the different balance of materials that would be exposed during the different break categories and then we looked at, I looked at different temperature profiles, different pH profiles. In using the WCAP calculator we looked at the amount released, without passivation, and I looked at the amount released over 30 days with sprays on, the amount released with six and a half hours of spray.

So you see the smaller amounts of chemicals released as what we would expect. So we did do an evaluation such as that and we wrote it up in a white paper.

And then we went a step further and we took advantage of the passivation. There is some work that we were doing where we've gotten a new aluminum release equation.

Kerry developed it from tests we did at UNM and we applied that to our WCAP calculator and we see even smaller release. So we did look at that and we see that there is a, an uncertainty band with some risk margin, but as far as applying it into the statistical analysis, we haven't gotten there yet.

DR. LETELLIER: It's important to note that the chemical environment models were applied against, they were exercised against the tests where we had periodic sample concentration data so that we could calibrate in a sense or confirm that the models were useful for this environment.

MR. KEE: You might want to point out too that the hypothesis for not having the trisodium phosphate present maybe plausible. But these are in, this chemical is in dry form in baskets in containment.

MEMBER SCHULTZ: I understand that.

MR. KEE: So people go, yes.

MEMBER SCHULTZ: I’ve seen it.

MR. KEE: So.

MEMBER SCHULTZ: And it's checked, right?

MR. KEE: Yes. And there's a surveillance that they check and make sure it's at the right height.

MEMBER SCHULTZ: It doesn't go anywhere.

MR. KEE: It didn't go anywhere.

DR. LETELLIER: So now I think we've thoroughly discussed, I hope you understand how this approach was applied.

We were challenged on the fact that we didn't have a large data set to fit a correlation of this kind. So we did some supplementary analysis to look at testing under a real strainer conditions and find a plausible, I'm using plausibility arguments with a plausible bound that would provide a scaling factor in terms of the so called superficial loading, which is nothing more than the mass of the chemical per unit strainer area.

We're running very short on time, I think that you have a supplementary report describing this approach. If not it can be provided.

CHAIRMAN BANERJEE: Well why don't we just make sure that we have it and let's move on. Because I want to get this done by 5:30.

DR. LETELLIER: Okay.

CHAIRMAN BANERJEE: The whole thing.

DR. LETELLIER: Then we would be skipping --

CHAIRMAN BANERJEE: Yes.

MEMBER SCHULTZ: Yes.

DR. LETELLIER: I guess the conclusion of the L* evaluation was that it supports the position that the multiplicative head loss factors do not underestimate our risk. That in fact we get much closer doing it with real realistic data.

MEMBER SCHULTZ: Bruce, why don't we go to 75 and that's where you --

DR. LETELLIER: Yes.

MEMBER SCHULTZ: -- providing the conclusion.

DR. LETELLIER: This is a conclusion slide.

DR. WALLIS: Since you don't have any at all.

DR. LETELLIER: I've mentioned a couple times we're working towards a consensus with --

DR. WALLIS: So we should reduce the risk by a factor of 24 because you're --

DR. LETELLIER: It doesn't translate it quite that way --

DR. WALLIS: So usually --

DR. LETELLIER: -- actually. It relates closer to the means actually. And we have studied that as well. So let's continue with conventional debris head loss on slide Number 77.

As I've explained, the chemical head loss is applied on top of a conventional debris estimation. So you must have a model for that.

Our model assumes a full bed compaction to familiar limit of 65 pounds per cubic feet. And this was done primarily to obviate the controversy with a choice of a compression model.

DR. WALLIS: That takes enormous pressure to achieve that. You never get a pressure drop big enough to make that.

DR. LETELLIER: I'm glad you agree. Because I'd like to use a smaller number.

DR. WALLIS: I mean it's a pressure drop across the bed that compacts it.

DR. LETELLIER: That's correct.

DR. WALLIS: And you're predicting a very small pressure drop.

DR. LETELLIER: This is basically the sedimentation limit where if you took sludge or sand, silt and it was finely divided and compacted you could reach the --

DR. WALLIS: If it's silt. But if it's fiberglass you'd have a terrible time compressing it to that.

DR. LETELLIER: I don't disagree with you.

CHAIRMAN BANERJEE: But it could be full of particles.

DR. WALLIS: Well that's where the problem is.

DR. LETELLIER: It's always full of particles and it always contains fiberglass.

DR. WALLIS: And if it has micron sized particles you're in real trouble.

DR. LETELLIER: Indeed. And so you fully understand that this is driven by the size distribution --

DR. WALLIS: Yes.

DR. LETELLIER: -- and the density, the material density of the particulate. And almost more importantly the thickness of the bed.

This sets a limit on the need thickness and the composite porosity. And I think, I think it's clear to everyone that we are predicting this as a function of time so that the properties of the bed actually change as the different constituents arrive.

Now to simplify the LAR calculation. Essentially all of the debris is introduced immediately. So it's always in a homogenous mixture. But each break scenario has a different ratio, different proportion based on its location site.

The second important assumption of our model is that we applied a Factor 5 uncertainty bound on top of this estimate. Which we believe is consistent with the observed variability in head loss between similar tests and alternate facilities.

DR. WALLIS: I think that Pacific Northwest got factors of 100 by having material arrives at different, in different sequences. The same amount of stuff. That's 100 and not five.

DR. LETELLIER: We would like to look at their ultimate compaction limit, actually. Because those were real tests with real fiber compression.

And in fact that is the challenge, is how do we calibrate this Factor 5 uncertainty bound to be consistent with observed evidence?

In some sense our choice of a full bed compaction reduces modeling uncertainty. Because we're no longer debating the benefits or the competing accuracy of alternate forms.

Factor 5 has been called a number of things like a safety margin or a safety net or a band-aid. But in fact a factor of 5 is not dissimilar to out treatment of other physical uncertainties.

For example, the ZOI size, there is acknowledged uncertainty there and there's clearly some debate about what factor of margin is represent. A 100 percent assumed coatings failure also has similar factors.

DR. WALLIS: Well what concerns me is I'm most familiar now with the downstream effects tests because that's what we've seen most recently. And it seems, if you look at the data, that nothing much happened. And then you change something by a factor of 2 or something and suddenly the pressure drop goes up by a factor of 100.

And it's not as if it's a linear thing, something happens to completely block the pores in the bed and takes off.

DR. LETELLIER: That's exactly right.

DR. WALLIS: So a factor of 5 doesn't really account for that, does it?

DR. LETELLIER: It depends on what the local porosity limit was compared to this compaction limit.

DR. WALLIS: Oh.

DR. LETELLIER: And you're exactly right, we've experience that ourselves in a case, at the CHLE test facility, we used a blender prepared material that contained a high proportion of fractured glass or shards.

DR. WALLIS: Yes.

DR. LETELLIER: And the beds were very stable for many, many hours until the column was bumped or there was some slippage and suddenly the head loss started to increase.

The post-test we observed dimples. Dimpling formed at the perforation plate and microscopic examination suggests that there was an impaction process that totally blocked the flow. The flow porosity.

And so that's the real question, is first of all the debris composition and prep. Back to your original comment, where does it come from, what does it look like.

And then your ultimate information and knowledge about the morphology or the configuration of the bed. What is the local porosity.

We've constructed a model that allows us to look at parameter variations with different STRATA and different combinations of those parameters.

The bottom line is that these two are important assumptions, full bed compaction and the Factor 5, they're applied on a modified version of NUREG 64. So in the LAR analysis you will see very familiar formulas from this document. With exception of the compression model.

All right, so we were asked to provide information about --

DR. WALLIS: Why is 65 pounds per foot cubed full bed compaction?

CHAIRMAN BANERJEE: Right. I was supposed to, going to ask you that. What is that?

DR. LETELLIER: About your words?

DR. WALLIS: Why 65 pounds per foot cube?

DR. LETELLIER: I was going to quote the comment that it would take an extreme amount of pressure to achieve that density.

CHAIRMAN BANERJEE: But that's not the density you would get if you filled up all the pores with particles?

DR. LETELLIER: This is a value that you will find in NUREG/CR-6224 that represents a nominal compaction limit for the iron oxide sludge in the boiling water reactor --

DR. WALLIS: So it comes from that?

DR. LETELLIER: Yes.

DR. WALLIS: But if you fill-up, if you have a fiberglass bed, which is reasonable thick, and you fill-up, fill it up completely with ten micron particles, you get thousands of psi.

CHAIRMAN BANERJEE: You get thousands of psi but the density could be above 65.

DR. WALLIS: But that's --

CHAIRMAN BANERJEE: Depending on the density of your micro particles.

DR. WALLIS: You fill-up all the pores --

CHAIRMAN BANERJEE: Yes.

DR. WALLIS: -- with very fine particles you get complete blockage, yes.

CHAIRMAN BANERJEE: But anyway.

DR. LETELLIER: The geometry, the

calculations for limiting bed thickness are not difficult to trace, but it does depend on understanding the full size distribution of your source train.

DR. WALLIS: Well how it gets in there. In the order in which it arrives and all that stuff.

DR. LETELLIER: Yes. That can be investigated through parameter studies. We've looked at two of particular interests.

One I've already mentioned, the local impaction in the orifice of the plates, and the second you've already mentioned, is a thin layer of chemicals on the top of a preexisting bed. Both are locally low voracity conditions that have different influences on bed response.

CHAIRMAN BANERJEE: So this correlation, of course, has been around for a long, long time. I remember, when was it, '64? I mean we've seen it in various guises going back, what almost 15 years or something?

And the staff and ACRS have never really accepted this and we've always asked for testing. For under flow typical conditions. So what is it about your case which allows you to use this rather than testing?

DR. LETELLIER: Well first of all, one of our incentives for adopting a model in general is so that we can examine some of the subtle interactions between the particulate composition, the bed compression.

I personally believe it's essential to have a model so that we can understand those potential interactions. And also so that we can interpret and plan for the testing that's required to prove principles and performance.

So in essence we adopted something that was familiar, because that's a good basis for conversation.

We show you in following slides that we have alternatives that address some of the known deficiencies with 6224. And we were prepared to proceed down that path, depending on the feedback we received.

DR. WALLIS: What is this SiC and what is the acrylic?

CHAIRMAN BANERJEE: Particles.

DR. LETELLIER: Silicon carbide is nothing more than an abrasive.

DR. WALLIS: What size is it?

DR. LETELLIER: It comes in various sizes according to the supplier. According to manufacturer. Notionally 10 microns, 20 microns.

DR. WALLIS: 10 microns tends to go right through the fiberglass.

DR. LETELLIER: It can unless you have other particulates present.

DR. WALLIS: Don't think about the test with Cal-Sil. And if Cal-Sil was sort of filtered to get out the big particles, than it had almost no effect. But then, I think it's Pacific Northwest did the experiments where the Cal-Sil was blended, sorted to the range from 1 micron to 30 microns or something.

That was very effective of blocking things because the big particles got caught and then the smaller ones and smaller ones until the thing filled up. So the range of particle sizes is important.

DR. LETELLIER: Indeed it is.

DR. WALLIS: If you just use big ones or little ones, you've got a completely different effect than if you use a plant.

DR. LETELLIER: Indeed that is all true. You're familiar with the latent debris studies that were done some 10 to 12 years ago that offers a formulation for prototypical size distribution.

DR. WALLIS: This is the basis of that NUREG you were --

DR. LETELLIER: No, that would have been a LANL report that --

CHAIRMAN BANERJEE: Yes, I remember that.

DR. LETELLIER: -- latent brief characterization. The point is that all tests conditions that are intended to be prototypical, we do include elements across the whole size range.

One of the dominant influences, which is not fully satisfied, is the disposition of failed coatings which are presumed to fail in their constituent part particular base. Because of the particular large loading, this has become a dominant influence in our head loss.

DR. WALLIS: I've seen tests where flakes completely block the strainer.

DR. LETELLIER: At the very low velocities it's questioned whether they will transport.

DR. WALLIS: Yes.

CHAIRMAN BANERJEE: They float sometimes. I've seen them float --

DR. LETELLIER: This is very low velocity. You've seen the photographs where the strainer flow area is elevated above the floor. So you have to have sufficient lift.

CHAIRMAN BANERJEE: Yes. So let me ask you the bottom line here.

MEMBER CORRADINI: Yes. Well I was just going to ask, we're still 30 slides way from --

CHAIRMAN BANERJEE: Yes. So what is the, I mean suppose you didn't use this correlation but had to revert to using your testing with some range of variation of variables and so on, would you get, what would this do to this whole approach? The risk informed.

Would it make it, if you were not able to use this correlation, would it make any difference?

DR. LETELLIER: Well first of all I would challenge anyone to demonstrate that the test data are sufficient without a model. So they go hand in hand.

And the material that we've just skipped on the L* correlation shows at least one example of how you can use prototypical test data to provide bounds, envelopes.

In our context we're using that to calibrate our measures of modeling uncertainty so that we're not introducing gratuitous conservatism, that we're actually within reasonable ranges.

CHAIRMAN BANERJEE: So you need this

correlation to make your case. Is that what I understand?

DR. LETELLIER: There are alternatives. This is the path that South Texas has chosen.

CHAIRMAN BANERJEE: Okay, so what are the alternatives?

DR. LETELLIER: It would look very similar to the L* correlation. We would base it on performance testing, we would have to have a preexisting agreement on the challenging debris loads and we would look for bounding envelopes under a range of flow and composition.

CHAIRMAN BANERJEE: And would it substantially change the case you've made?

DR. LETELLIER: Depends on the results. Our --

CHAIRMAN BANERJEE: But you know roughly what your results, you've done some prototypical testing surely.

DR. LETELLIER: Yes.

CHAIRMAN BANERJEE: And you probably got horrible results, right?

DR. LETELLIER: It could substantially improve our results.

CHAIRMAN BANERJEE: Okay.

DR. LETELLIER: Because conservatism's were introduced.

CHAIRMAN BANERJEE: But those are all for large break LOCAs that you've done your prototypical testing, is that, your prototypical testing was done for large break LOCAs, right, with the loadings and everything?

DR. LETELLIER: Our strainer performance testing is done for both the DBA condition and for a thin bed loading under --

CHAIRMAN BANERJEE: You've done it for both?

DR. LETELLIER: Yes. Now one following slides, which we shouldn't dwell on, it will, some footnotes comments on some of the conditions for the tests were performed that aren't completely accepted by the staff. Some surrogates were used, some smaller ZOI was used for performance, strainer performance test.

CHAIRMAN BANERJEE: So maybe the most valuable thing, I'm just speaking for myself here, would be to see comparisons of your tests with this correlation. Your own tests. Have you got some results to show us there?

DR. LETELLIER: Let me, yes. We can flash through the slides and look at the right hand column for some of the observed maxima. And on Slide 81 is a comparison of the components that are observed using the LAR formulation.

Just to note that the cleaner strainer head loss is added as an independent term. Conventional head loss, this is data extracted from an ensemble of scenarios and these are the maximum factors.

So your immediate inclination is to add the numbers. And I would caution you, they don't add up. They're independent maxima.

Maximum conventional head loss is in the range of other conventional head loss tested under DBA conditions.

The chemical head loss that's induced by our factors is very large and it's in the range that you observe. But --

DR. WALLIS: Well there's much too much.

MEMBER CORRADINI: Since I can't, but it would only be applicable under thin beds, according to what you explained earlier. Is that not correct?

DR. LETELLIER: That's possible. But we've taken that penalty for all scenarios according to the exponential --

DR. WALLIS: But with this sort of a pressure drop, the pumps won't run.

DR. LETELLIER: Well obviously. Yes, obviously you failed your threshold long before this.

CHAIRMAN BANERJEE: But this are Sil calculated. I was --

MEMBER CORRADINI: Yes, he wants --

CHAIRMAN BANERJEE: -- I had a much more focused question. You're using 6224 and the correlation which many of us have seen. So let's just say it's a correlation.

How well does that agree with the data that you've taken for your, you know, you must have taken some data yourselves, right --

DR. LETELLIER: Yes.

CHAIRMAN BANERJEE: -- from --

DR. LETELLIER: That's actually the --

CHAIRMAN BANERJEE: -- the CDI or whoever did that.

DR. LETELLIER: Described on Page 78 there's a set of test conditions for high temperature vertical loop testing.

CHAIRMAN BANERJEE: Right.

DR. LETELLIER: And the 624, 6224 traditional model was compared to these --

CHAIRMAN BANERJEE: Yes.

DR. LETELLIER: -- are shown to be conservative. I did not perform the tests and I'm not prepared to discuss them.

CHAIRMAN BANERJEE: So you have those results somewhere?

DR. LETELLIER: Yes.

DR. WALLIS: I believe the tests were only with 10 micron silicon carbide, I wouldn't think they were represented here.

DR. LETELLIER: Well, that's a different question. We were asked to show the performance of the model.

CHAIRMAN BANERJEE: No, no, yes. The performance of the --

DR. WALLIS: If the silicon carbide had been trapped in the fiberglass --

DR. LETELLIER: Right.

DR. WALLIS: -- you'd have gotten numbers like the ones you just showed us. Or even more. Because you can simply calculate the pressure drop, you would yet if it all got trapped.

DR. LETELLIER: I'm not sure I understand your observation. We have both particulates and fibers in these tests.

DR. WALLIS: Yes, but did you, you got 10 micron size particles?

DR. LETELLIER: That's a nominal size over a range.

DR. WALLIS: Yes. But you can easily calculate what the pressure drop would be if the bed filled up with those particles. And it's --

DR. LETELLIER: That's right.

DR. WALLIS: -- a 1,000 psi or something like that. It's humongous.

CHAIRMAN BANERJEE: So these results that you show are the results of your strainer tests done in 2008? On Page 79?

DR. LETELLIER: Yes.

CHAIRMAN BANERJEE: And how did your, how well did 6224 agree with this? Have you got some comparisons?

DR. LETELLIER: I can only show, this afternoon I can only show you a comparison of the tests to the modified results, which is what we implemented in the quantification.

CHAIRMAN BANERJEE: Right, but I'm just looking for, before you go anywhere else, you're using a correlation, right?

The question is, how well does that correlation predict this test? Before you go anywhere else, does the correlation predict it reasonably well, does it come anywhere near?

DR. LETELLIER: So the challenge is always the vent configurations and making an assumption about the interstitial porosity of the test.

CHAIRMAN BANERJEE: Right.

DR. LETELLIER: And that's the reason why we've obviated that concern. So we can show you how the assumptions bound the performance based on our knowledge about what's present in the bed and what it looks like internally.

But in order to have a good match with data, you need to have a well-controlled test, like our vertical loop, which was composed of equal proportion, I'm sorry, constant ratios of particle to fiber that were intentionally mixed homogeneously so that after complete filtration occurs we have a reasonable good understanding of porosity.

CHAIRMAN BANERJEE: But coming back to

these tests, these were done with a prototypical strainer set, right? One of those things?

DR. LETELLIER: Yes.

CHAIRMAN BANERJEE: Sucking some flume somewhere, right?

DR. LETELLIER: Yes, the model.

CHAIRMAN BANERJEE: Where was this done? Was it done at Alden Labs?

DR. LETELLIER: Yes.

CHAIRMAN BANERJEE: This was done, you put some debris and stuff and --

MR. KEE: Some chemicals --

CHAIRMAN BANERJEE: -- this is what you got?

MR. KEE: Yes.

CHAIRMAN BANERJEE: Okay. So we understand more or less that these were prototypical conditions?

MR. KEE: Correct.

CHAIRMAN BANERJEE: Okay.

DR. LETELLIER: That was the intention to satisfy --

CHAIRMAN BANERJEE: And you reworked the curves and stuff based on this with time, how this built up?

MR. KEE: Show those results, we got them. We got them, right?

CHAIRMAN BANERJEE: I guess my question, my don't have to answer it now, but you have to answer it at some point is, how does your correlations that you're using, 6224, so this table, that question, without any massaging, nothing, agree with the series of strainer tests you've done?

It may or may not agree, but it could be interesting to know how well it does or how badly it does.

MEMBER CORRADINI: I mean, I guess Sanjoy's question is kind of where I was going, and then I noticed at the end your, one of your conclusion things, 20 slides later, is here that the modified 6224 model does not under estimate the risk. And I'm trying to --

CHAIRMAN BANERJEE: Risk, yes.

MEMBER CORRADINI: -- means and, yes, I know I'm trying to make, I'm trying to understand if that means it's conservative well or to the data or not?

CHAIRMAN BANERJEE: Yes, I think we make, we ask a fair question. How well does it agree with the data? Without --

MEMBER CORRADINI: But I don't see anything here that answers your question.

CHAIRMAN BANERJEE: Yes. Well, but they have an opportunity to do it. We have an infinite amount of time before we see this again. Not infinite.

DR. WALLIS: But when we see these LANL test report and data, and how you process them to see if they agree with your correlation.

DR. LETELLIER: There are test reports. But we have not built a one to one correlation for --

DR. WALLIS: Can we see that? Can we, do we have that model?

CHAIRMAN BANERJEE: Can we see this --

DR. WALLIS: Have this LANL report --

CHAIRMAN BANERJEE: -- test report? The STP.

DR. WALLIS: -- on Slide 78?

DR. LETELLIER: Yes.

MR. KEE: Yes.

DR. WALLIS: We have that?

MR. KEE: I think it's, didn't we submit it?

DR. LEAVITT: Didn't you say --

DR. LETELLIER: Yes, maybe --

DR. LEAVITT: Yes, that one submitted.

MR. KEE: I think you have it already with the RAI.

CHAIRMAN BANERJEE: Okay, so you think we have them --

DR. LEAVITT: -- with the RAI.

MR. KEE: That's true.

CHAIRMAN BANERJEE: We have them, we just have to locate them. That's fine. We should look at the reports, we should look at the predictions of the correlation and see how well they agreed.

Did you perform some comparisons with the correlation or you did not?

MEMBER CORRADINI: Can you remember which of the RAI responses it was? Just --

DR. LETELLIER: It's ID something.

MEMBER CORRADINI: Sorry.

MR. KEE: I'll tell you what I remember in just --

DR. LETELLIER: Yes.

MR. KEE: -- in a minute.

MEMBER CORRADINI: Thank you.

CHAIRMAN BANERJEE: Okay, so I think we are just looking for the information right now. We can do our own --

MEMBER REMPE: But I'd like to hear the answer to your question, even if we find the RAI, did you compare the correlation to the data? Because I think I heard earlier, we didn't do that.

DR. LETELLIER: Okay, so the answer is yes and no. Almost always. The correlation as modified has not been compared to the test data one, and it's as a time series.

However, later in the slide deck you'll see an alternative correlation which has been compared to the time series. And the only purpose in doing that was to help us calibrate the uncertainty bound, the factor of 5, to make sure that it was appropriate.

We've achieved very good agreement for well controlled tests. However, that does, it's not a sufficient criteria for leaving in a 15 percent agreement. Because we know there's always uncertainty in the --

DR. WALLIS: Now these are tests of the strainers or of the core?

CHAIRMAN BANERJEE: Strainers.

DR. WALLIS: The strainers, right?

DR. LETELLIER: This is, what we're

speaking of is the vertical head loss test. Which --

DR. WALLIS: They couldn't --

CHAIRMAN BANERJEE: They have not done any core tests. They told us that already. They didn't do any core tests.

DR. WALLIS: They're not specific to the design.

DR. LETELLIER: Nothing inside the fuel channel, no.

DR. WALLIS: Yes.

CHAIRMAN BANERJEE: So, but let's stop with the strainers.

DR. LETELLIER: Keep in mind there is a companion report that does describe the strainer tests, which were done in the flume, on these strainer modules. Those are both available for you to read.

CHAIRMAN BANERJEE: And the comparison is with the modified correlation? That you said the results are compared to your modified correlation?

DR. LETELLIER: That step has not been done. What I was offering was later in this presentation, at your convenience, we're looking at an alternative correlation that addresses some of the deficiencies, known deficiencies of 6224. And it has been compared to the vertical loop testing.

CHAIRMAN BANERJEE: Well not to these flume tests.

DR. LETELLIER: That's correct. That step has not been taken.

CHAIRMAN BANERJEE: Okay. So at the moment there is no comparison to, either the 6224 correlation or your improved or modified version to these flume tests? Or have I got it wrong?

DR. LETELLIER: The basis of the LAR does not include those comparisons. No, I hate to speak too quickly because the flume tests have been analyzed and there are likely to be studies where traditional 6224, as is, was compared to those results.

CHAIRMAN BANERJEE: But if there are we would like to see that comparison. Let's follow that up.

I mean, you know, look, we know the short comings of 6224, so the fact that you don't have a perfect comparison doesn't mean that there's something wrong. We just want to see how good or bad it is.

DR. LETELLIER: Sure.

CHAIRMAN BANERJEE: That's all. We'd like to know that.

So I think with that, I'm just wondering how much further we want to go into this. Because in the end you've got an equation which gives you pressure loss versus various flow parameters and things like that. That's really what you're trying to showoff here, right, based on some data?

And it maybe some modified version of 6224, so perhaps what we should do is, unless you have a very important set of things to show, show us what you're using to correlate the date, the correlation that you finally chosen, and how well it agrees with the data. If not your own data, whatever database you want to.

DR. LETELLIER: At a future date?

CHAIRMAN BANERJEE: Yes.

DR. LETELLIER: That's your recommendation?

CHAIRMAN BANERJEE: Yes.

DR. LETELLIER: Understand.

CHAIRMAN BANERJEE: Because that's the bottom line. And uncertainty and everything that you perform would be based on taking this as a correlation and putting certain uncertainties on various parameters and within the error bands of what you've seen in comparison to the data. I imagine that's what you're going to do, right?

DR. LETELLIER: Indeed. In fact that is one of the powerful advantages of a model like this so that we can exercise it against the rich spectrum of compositions that come from our break analysis.

CHAIRMAN BANERJEE: Right. So you want to be able to evaluate the effect of various parameters like particle size or fiber size and all these exotic things.

DR. LETELLIER: It's not just a --

CHAIRMAN BANERJEE: Chemical effects.

DR. LETELLIER: -- academic interest, it's important to help us prioritize our research investment. If it turns out that coatings failure is a dominate aspect then we need to understand why that it's driving our answer.

CHAIRMAN BANERJEE: Right. But that's really, we want to see the comparison with whatever data you've got at the moment.

DR. LETELLIER: Okay.

CHAIRMAN BANERJEE: And what are the most important effects that --

DR. LETELLIER: At your leisure I'd encourage you to browse through the alternate correlation and so called VISTA correlation --

CHAIRMAN BANERJEE: Yes, this is on, what, which slides? 84 and 85 or?

MR. MURRAY: Without the dialogue the slides probably, will probably be more beneficial with the information that we actually provided in the RAI responses. I think that would be a better opportunity because then you can read the details without --

CHAIRMAN BANERJEE: But if you just provide the RAI number to Mark, we'd followup.

MR. BANKS: I've got that.

CHAIRMAN BANERJEE: Okay. We just want to move on because I don't want to miss out on the last part of your --

DR. LETELLIER: I --

CHAIRMAN BANERJEE: So whatever is the most important you can tell us now, but I want to finish by 5:30 if possible.

DR. LETELLIER: We have --

CHAIRMAN BANERJEE: And then have a little closed session so we are out of here by 6:00.

DR. LETELLIER: Okay, so we still have 45 minutes?

CHAIRMAN BANERJEE: Yes, but we also want to hear about your scenarios, you know, that you ran.

DR. LETELLIER: That's what we're going to do.

CHAIRMAN BANERJEE: Yes.

MR. KEE: I say let's go into that if --

CHAIRMAN BANERJEE: Yes.

DR. LETELLIER: Let's jump to Slide 90. So this exercise of comparing correlations to data and the data to the assumed implementation has been an exercise in uncertainty analysis. Primarily model uncertainty.

And the supplementary approach is L* and VISTA. Our conclusion is that indeed they support the choice of a head loss model and help us calibrate our understanding about the Factor 5 uncertainty.

But there are also other dimensions of uncertainty analysis and we've only touched on a few of these. We talked about parameter uncertainty, which in our analysis thus far, has been distributions applied to physical parameters.

The distributions sometimes have been calibrated through actual test data. For example the filtration parameters are based on a repeated tests of prototypical conditions.

In the case of the chemical head loss correlation, it's been somewhat of a subjective probability distribution that supports the behavior of the data.

Nonetheless, physical uncertainties have been sampled and propagated through the study. There's a very good sensitivity analysis report.

University of Texas has documented the perturbation studies, if you will. How much change in a dominate parameter leads to change in risk.

We've talked a little bit about the mechanics of air propagation --

CHAIRMAN BANERJEE: But that depends on a set of models that you got, correct?

DR. LETELLIER: Yes, that's right.

CHAIRMAN BANERJEE: And they've got all the models lined up in that report.

DR. LETELLIER: Which are document, primarily documented in Volume 3 of the LAR.

The mechanics, we haven't talked about in great detailed. I've mentioned, talked about this as a statistical design with variance reduction strategies using nonuniform type of sampling.

This is residual sampling here. This

tells you, are you done, have you investigated enough combinations? And we control this to better than five percent residual error.

We'll spend our remaining time on a couple of, three specific examples. And there is a body in the center here that we can touch on lightly. Perhaps not spend too much time.

This topic is broken into three parts, first, again, to emphasize the role of CASA Grande in this apparent scenario analysis.

DR. WALLIS: What's the slide number?

DR. LETELLIER: This is Slide Number 92. The second part is the calculation elements which, which basically a parking lot for assumptions that I know you'll be interested in, but we don't have to dwell on this. The examples of both success and failure are shown at the end in very specific detail.

Now moving to Slide 94. Keep in mind that GSI-191 has always been a data intensive problem. Multi-disciplinary. And largely engineering calculations have been distributed over five or six key reports and assembled for deterministic studies.

CASA simply automates that an accommodates rigorous uncertainty propagation. So it's a tool for studying the driving elements that lead to risk contribution.

Again, we've talked a fair amount about how it complements the PRA by providing conditional probabilities for different damaged states.

Gained a lot of quantitative insights on subtle effects, accident progression. Time that we would have not known otherwise, and it's become the basis for risk attribution, if you will, so we can look at dominate factors and consider future plant actions.

CHAIRMAN BANERJEE: Did you, are you going to tell us what insights you gained? That would be very interesting to know.

DR. LETELLIER: Some of those are evident in the example problems. The sensitivity analysis report would also be an excellent place to look.

Initially experts had a list of 15 top parameters that we thought might be important, and ultimately three to five were actually of interest.

CHAIRMAN BANERJEE: Are you allowed to tell us what those were?

DR. LETELLIER: Indeed. Top of the list is the core fiber limit, 7.5 grams, is a dominant risk driver.

The next in line is the, yes, the filtration function. The filtration efficiency of the strainer loaded with debris.

Which you'll find a very good analysis report on how the tests were conducted to look at the effect of concentration, debris loading rate, velocity, etcetera. And also how we optimized the parameters of a model that actually accounts for the time dependent accumulation of fiber and the shedding that occurs on a much different time scale.

The particulate loading has got to be the third on the list. And that's primarily involved with coatings failure as a dominate particulate source.

MEMBER STETKAR: Coatings failures --

DR. WALLIS: -- shedding of particulates?

DR. LETELLIER: We haven't tried.

DR. WALLIS: That seemed to be very important. Because all the particulates go through to the core. Then they're more likely to fill-up the bed.

DR. LETELLIER: Indeed. And like I said, our strategy has been to double count the particles. To, first of all for our head loss calculations we assume they're a 100 percent resident in the debris bed.

And for the purpose of core blockage we

assume that the testing limit already accounts for their presence. And we can verify that.

DR. WALLIS: They assume that they all bypass the strainer?

DR. LETELLIER: We'll have to revisit the assumptions of the test. In essence yes.

CHAIRMAN BANERJEE: Okay, let's go on.

DR. LETELLIER: Let's look at Slide 95 at the bottom three bullets. Might add just a little clarity about CASA Grande.

We've already seen early this morning the time dependent equations that attract the mass throughout containment.

So CASA is actually solving this differential equation subject to the conditions of a plant damaged state for available flow. But on the other had it does not do anything fancy with coatings failure, that it's accepted as an input. Temperature profiles, boil-off rates are accepted as input files.

The function is to integrate these physical models and propagate those parameter uncertainties into conditional failure of the ECCS.

MEMBER CORRADINI: So just so, pick one example. Temperature is used only to attract where things may precipitate?

DR. LETELLIER: And also for NPSH to track a margin of coverage --

(Simultaneous speaking)

DR. LETELLIER: That's right. That's it. So the calculation elements is not a comprehensive list of topics, but we tried to pick those that you might have a keen interest in.

We probably should have presented this much earlier, but this is a list of the scenario failure thresholds. The obvious ones are NPSH margin. The structural margin. Whether the, it mechanically collapses under the load.

We haven't talked much about void fraction error evolution. It's an important limit.

We have talked about the core fiber load, 7.5 grams for a cold-leg-break in relation to boric acid precipitation.

But you could imagine core loads for other reasons. And those, these have not been applied essentially because of the assumptions we've already explained.

CHAIRMAN BANERJEE: How far away are you from the hot-leg limit? I mean if there were some uncertainties in this bypass, so would you get hot-leg limited?

DR. LETELLIER: For 15 grams?

CHAIRMAN BANERJEE: Yes.

DR. LETELLIER: A hot-leg limit of 15 grams per fuel assemble? If we were to substitute 15 for 7.5 we would reduce our risk by about 30 percent.

MEMBER CORRADINI: See I think, are you --

CHAIRMAN BANERJEE: I was asking about more of --

MEMBER CORRADINI: Loading?

CHAIRMAN BANERJEE: No, I was just saying that if you, let's say you found that the cooling you expected to get from the leakage into the upper plenum was reduced or your RELAP5 calculations were wrong and you went back to a much more conventional hot-leg limited scenario, which probably would drive you to the 15 gram limit, how far are you from that scenario in terms of, I guess I'm not able to formulate the questions because it's not all that clear in my mind, but it's very unusual to be cold-leg limited on this, okay. So that's what you are in this case.

And the reason you are cold-leg limited is that you brought this leakage path which takes your stuff off of the top which screens on the top of the core and hopefully that cools it. That's why you're not hot-leg limited.

But is there, I mean is it pretty close these scenarios? I mean would you have to just be wrong a little bit in order to get into the hot-leg limit?

Because the 7.5 and the 15 are pretty close to each other because, actually because you're bypassing stuff out, you know, if all the flow went to the core. I mean you'd be essentially similar conditions, right, would give you the 15 grams?

Because they are losing half of it through your break. At least I think you are losing a lot of it through your break. I don't know, this is all mis-conformed so I can't think in those terms. But --

DR. LETELLIER: We would --

CHAIRMAN BANERJEE: Because you got small breaks, medium breaks, all sort of things there.

DR. LETELLIER: We would have to think carefully --

CHAIRMAN BANERJEE: Yes.

DR. LETELLIER: -- about the hot-leg limit that we adopt for South Texas, specifically.

CHAIRMAN BANERJEE: If you have to get the, I mean what would it take to become hot-leg limited, that's really the question I'm asking? Much?

DR. LETELLIER: We can answer that question, but I'm not prepared this afternoon.

CHAIRMAN BANERJEE: Yes, don't do an answer now --

DR. LETELLIER: Yes.

CHAIRMAN BANERJEE: -- but would it just be some blockage at the top through these holes or something wrong with your RELAP5-3D calculations so you got stuff happening in the middle of the core and water not reaching there?

DR. LETELLIER: Sure.

CHAIRMAN BANERJEE: Who knows. Think it through.

DR. LETELLIER: In very early quantifications we used hot-leg limits, upwards of 75 grams per fuel assembly for reasons that we could revisit, but I'm hesitant to say that the 15 gram limit would lead to acceptable results because of the flow path dominancy --

CHAIRMAN BANERJEE: Okay.

DR. LETELLIER: -- that you discussed.

CHAIRMAN BANERJEE: Well you got a

interesting result, which is in fact the 7.5 to 8.5 is above the limit you would expect if it was cold-leg limited. Because that's about the right number given your fuels assemblies.

You know, we've seen other tests which suggests that that would be, for a cold leg break, roughly the number. Because it's consistent.

MEMBER CORRADINI: Well what you repeated at the end there if it were 15 not 7.5 you would decrease the risk by, how is it 30 percent?

CHAIRMAN BANERJEE: Well I don't know that.

DR. LETELLIER: Cold-leg.

MEMBER CORRADINI: For cold-leg. But then he also, earlier in the day, it's been so long ago, I think it was today, he said that if I decreased it 7.5 to 5 to 4 to 3, it's very non-linear, it increases the risk quite dramatically. Do you remember that?

CHAIRMAN BANERJEE: Yes.

MEMBER CORRADINI: Okay. So it's like, it's kind of --

CHAIRMAN BANERJEE: Is there a cliff that's --

MEMBER CORRADINI: He quoted a bunch of

numbers that sounded, 7.5 things are, don't change very much anymore, but if I started backing that down, it changes markedly. But based on their calculational procedure.

CHAIRMAN BANERJEE: Yes. So if that, the question I guess that we all have is, imagine that, I have difficulty thinking in the space, but suddenly in deterministic space you always look for a cliff, right?

You want to find that, if I'm wrong on that 7.5 by a bit, does it increase the consequences enormously? That's what we're really after.

And what Mike is saying that if you reduce it say 3 of that limit, would it increase your risk enormously? That's really the question. And then could you have got it wrong by 2 grams or 3 grams and that gives you a big change?

DR. LETELLIER: Right.

CHAIRMAN BANERJEE: That's the sort of issue which is bothering us I guess.

DR. LETELLIER: Of course.

CHAIRMAN BANERJEE: And the same with the hot-leg, you know. If something slightly changes is it going to put you into a situation where the hot-leg actually starts to dominate the risk, in this case, and give you --

DR. LETELLIER: Complete answer to your observation about the hot-leg, in respect to a threshold, would actually require revisiting the thermal hydraulics with some definition of complete blockage. You would have to understand how much is too much fiber.

CHAIRMAN BANERJEE: You wouldn't even have to have complete blockage. All you would have to say is this cold calculation, I can probably find a good reason to say that it will not cool the middle of the core or something so that you get it over 800 degrees.

You know, which probably means fooling with two or three parameters. I'm sure we can figure it out, how to do that. Which won't give you that result.

DR. LETELLIER: One of the attributes of CASA that we have not exercised is actually placing an uncertainty distribution on the threshold of concern so that we can actually, in a single evaluation, sample that threshold.

CHAIRMAN BANERJEE: Well that's sort of interesting if you could do that.

DR. LETELLIER: And that's a reality. We're seating here today debating the accuracy.

CHAIRMAN BANERJEE: Because one of the things that we find is that you can flip the situation quite often. For example, you know, some reactors are large break LOCA limited, some reactors are small break LOCA. All Westinghouse plants.

And you get two peaks basically. One is the low down peak and you get the small break LOCA peaks. And some the low down peak is bigger, some the small break.

But a fairly small change in a set of parameters will flip one peak to the other. And you'll get different controlling phenomena completely there.

And that's really the issue if you get into the hot-leg limit, which is more usual compared to the cold-leg limit. What does it take to get to that and does that increase the risk significantly if you somehow flip into that? I don't know. That's the sort of question.

DR. LETELLIER: Clearly you have identified the key assumption that our hot-leg breaks have not been an issue of concern by assumption supported by --

CHAIRMAN BANERJEE: Well I guess it's your RELAP5 calculation, right? You say that. Okay.

Anyway, let's not dwell on that but continue.

DR. LETELLIER: Let's continue with computational elements, debris generation. We've already talked a bit about this.

The intention of revisiting these is so that you'll understand how they're implemented in a complete calculation of a single scenario start to finish. This doesn't have statistics involved with the exception of choosing specific numbers.

Every scenario that we examine has a unique debris combination. Because of transport ability, failure, fractions, etcetera. Has failed on qualified coatings, it has coatings damage inside of the ZOI.

We're using spherical ZOI for the DEGB and hemisphere, hemispherical randomly oriented ZOI for sidewall tears.

CHAIRMAN BANERJEE: So there's just a jet, right?

DR. LETELLIER: Yes.

CHAIRMAN BANERJEE: And you're randomly oriented with this?

DR. LETELLIER: Perpendicular to the pipe. The size of the ZOI are based on familiar damaged radii. We haven't changed any of those traditional assumptions. The coatings, damage zones are based on a WCAP formulation.

I don't want to give the impression that all of the assumptions we're talking about are completely approved or recommended, this is simply what you'll see in the example.

MEMBER CORRADINI: So the four bullets sounds easy, but it sounds, but to me it sounds hard as the dickens. So you somehow are going to be able to somehow go around the plant and say, this is the pipe, this is the weld, it might happen here, it's pointed this way, here's a hemisphere and here is the stuff that tears up. Have I got it about right?

DR. LETELLIER: That's exactly right. And we do it routinely --

CHAIRMAN BANERJEE: Need a CAD drawing of everything.

MEMBER CORRADINI: Okay, that's much more complex than it seems. Than it seems here, right? Or am I missing something?

DR. LETELLIER: The essentially steps that you've described are exactly what CASA does millions of times in an analysis.

CHAIRMAN BANERJEE: It's got a CAD drawing or something and it --

DR. LETELLIER: You'll see those pictures very shortly.

MEMBER STETKAR: One thing on unqualified coatings, and I didn't read much, but the second bullet just says failed unqualified coatings. How, where? Just within the zone of influence or everywhere?

DR. LETELLIER: Everywhere.

MEMBER STETKAR: Everywhere.

DR. LETELLIER: Yes.

MEMBER STETKAR: There was a discussion of transport of the unqualified coatings from the upper part of the containment too, are you going to get to that?

DR. LETELLIER: Yes.

MEMBER STETKAR: Okay.

DR. LETELLIER: That's right.

MEMBER STETKAR: Go on.

DR. LETELLIER: But by definition a qualified coating is resistant to this, to the environment. But it's not necessarily robust to the ZOI, to oblation zone.

Pre-tent and transport, a single, for insulation we used a single transport fraction to all of our scenarios. So the fractions are based on transport assuming sprays continue with only minimal holdup on gradings.

At this point in time the LAR is not sophisticated enough to have a specific transport fraction by location.

DR. WALLIS: It just says that some fraction of debris gets to the pool --

DR. LETELLIER: Pool.

DR. WALLIS: -- no matter what?

DR. LETELLIER: That's right.

DR. WALLIS: That's an enormous assumption.

DR. LETELLIER: Well but we're intentionally inflating that fraction by assuming sprays --

DR. WALLIS: How big is this fraction?

DR. LETELLIER: We'll see that in a moment.

CHAIRMAN BANERJEE: So everything that is close to this spray gets transported?

DR. LETELLIER: No, there's a fraction we're going to look at that.

CHAIRMAN BANERJEE: Okay.

DR. LETELLIER: So we have early arrival of debris. This is important, it's kind of subtle and it was a feature that we found.

A behavior in our model that it appeared that latent debris was a good thing. If you increased the amount of latent fiber, it tends to reduce your risk.

And we realized that the fiber and some of this early insulation is present at times zero when the pool starts to fill. And we applied that. We pre-coated the strainer with fiber, which improves your filtration efficiency.

Now we understand what's going on, now we can debate how we would like it to perform. All coatings failed in the first ten minutes.

CHAIRMAN BANERJEE: Very interesting results, right?

DR. LETELLIER: I've joked for years that adding fiberglass to your strainer is maybe not a bad thing.

DR. WALLIS: Making the strainer smaller is better too.

DR. LETELLIER: That's a design feature. Debris transport, we've already talked about the equations that are solved, this is not a sophisticated numerical solution, it's a simple, it's just a time forward integration.

We've already talked about how particles are retained on the strainer and yet also included in the threshold for core blockage.

We have a strainer penetration model that's calibrated and it's quite a, a nice piece of work I think.

In essence we've already talked about the fact that this is controlling the potential for core failure. It's not surprising. If you had no strainer at all, you would always fail in the core. It's the gatekeeper.

We have also talked about how the debris has a split fraction to spray, but we're not taking any credit for internal time lag. It magically comes back to the pool instantly.

The same thing is true for fiber that bypasses around the core. It just instantly --

DR. WALLIS: You have so much fiber that you're very dependent on having a strainer penetration low.

CHAIRMAN BANERJEE: It's a key model --

DR. WALLIS: -- strainer penetration which is surprisingly high. I mean they assume half the fibers go through it, you got to reduce it by a factor of 2,000.

CHAIRMAN BANERJEE: But most of the bricks are small, tiny little things.

DR. WALLIS: You have a much bigger requirement.

DR. LETELLIER: Yes, you've just cited the magnitude in terms of our proportion. And that's because South Texas is a fiber-dominant plant so it is a significant reduction. But the quantities are comparable.

DR. WALLIS: You're saying we have other plants that sort of assume that 50 percent goes through. Something like that. Which is, you know, all this are measured different from what you have to get.

DR. LETELLIER: The question is, 50 percent of what?

DR. WALLIS: Fiber.

DR. LETELLIER: I mean in terms of the magnitude it should scale with the number of fuel assemblies and the limit that's chosen.

MEMBER CORRADINI: You're using their fiber to help sift their fiber? So they've got a normal screen that capture it and sift it and therefore less gets through. But that's what I see is happened.

DR. LETELLIER: That's exactly right.

DR. WALLIS: You have to have long fibers than to sift out the small ones?

CHAIRMAN BANERJEE: What?

DR. WALLIS: You have to have long fibers to filter out the smaller short ones?

CHAIRMAN BANERJEE: Well let's go on otherwise we'll never end this.

MEMBER CORRADINI: You started it.

CHAIRMAN BANERJEE: No, I didn't start it, Graham started it.

DR. WALLIS: You said the penetration is a very --

CHAIRMAN BANERJEE: Go ahead. Go ahead.

DR. LETELLIER: It is realistic behavior that is shown by module testing. The NPSH calculation, we've already talked about, it uses standard plant geometries for the distribution manifold.

It does use the time dependent temperature and flow rate for each of the operating pumps and it's important to note that the scenario is deemed a failure if any of the pumps lose their required head.

At South Texas there are three complete

trains. Three low head, three high head, three containment spray.

Here we go. Okay, so here's our first example. Out of some, almost 700 weld locations and a continuum of break sizes, my first question is, which ones should we share with you today?

So here's a quick comment on the role of the CAD model in the LAR. First of all it introduces very important plant specific spatial relationships.

If the plant understands they have a problem types, then they know where to go look for it. It's a very heterogeneous system that depends on geometry.

We are clipping by robust barriers. The CAD models important for determining flood levels based on the amount of water that's available.

DR. LETELLIER: It means that the spherical ZOI are not allowed to extend beyond a concrete wall.

MEMBER CORRADINI: So, you have some specification if the wall it thick enough it survives in blocks?

DR. LETELLIER: We assume that all concrete walls have a robust jet. But we are not taking any credit for --

DR. WALLIS: But divert the jet though, so it goes somewhere else, isn't it?

DR. LETELLIER: We don't have that conversation many times. And the spherical ZOI is intended to account for that. In the past the CAD model has been used to support computational fluids, computational domains.

And generally the CAD, well, for South Texas it was developed under a QA program to support many additional applications, in addition to this. Here on the left is the CAD model as it appears in the commercial software, the engineering software tool.

And on the right, this is the CASA Grande representation. So all of the concrete is present. All of the insulation is present. On Slide 105, now we're going to get into these examples. We chose these examples from a list of the top contributors. And all of these examples were for a double ended use guillotine break.

So, you should be expecting what, large debris volume. You should be expecting spherical ZOI challenge, large challenges to the stainers. I just want to note that these are all for the base case, where all the pumps are operational. We are not in one of the five plant failure states.

MEMBER STETKAR: Well, you are. It's called State Number 1.

DR. LETELLIER: It's 1, Case 01. That's correct. All three examples were chosen from a single well to help me emphasize the effect of a random variability from some of the parameters. Just a moment to jump forward in my notes.

CHAIRMAN BANERJEE: What does those numbers, like 24 under the sump mean?

MR. MUNOZ: That means, that's how many sump failures were realized at that location. So, if you look at that first line it says, one success, 24, you know, 24 sump and zero vessel failures. That's just the count at that specific well location.

CHAIRMAN BANERJEE: Oh, I see.

MR. MUNOZ: And if you look at the second column that says, percent contribution, that's actually the percent value contribution. So, if you were to eliminate that top well from the analysis, if you were someway able to completely mitigate it, you would reduce the risk by 26 percent.

DR. LETELLIER: We chose the highlighted

line because it has an interesting variety of failure modes. It can fail at the strainer, at the sump, or it can fail by fiber accumulation in the core.

DR. WALLIS: What do those numbers mean, 13 modes of failure, or something?

DR. LETELLIER: Yes. You can look at the proportionality between these numbers. But the total number is simply the number of scenarios that were in this statistical ensemble. And remember earlier --

DR. WALLIS: Which is this now?

DR. LETELLIER: We're assuming multiple breaks on every well.

MEMBER CORRADINI: So, can I say it differently, something I've given? So, all these guys have 25?

DR. LETELLIER: Right.

MEMBER CORRADINI: So, does that mean with the one in the hyper cube sampling you selectively made sure that you sampled enough in every one of the bins?

MEMBER LOWERY: Okay. That's right.

MEMBER CORRADINI: And then the bins are spatially related? That is, you got the upper part of the structure somewhere here, somewhere there?

DR. LETELLIER: That's right. That's why

we went through the break selection --

MEMBER CORRADINI: Okay.

DR. LETELLIER: -- discussion earlier.

MEMBER CORRADINI: Okay.

DR. LETELLIER: It's very important that we --

MEMBER CORRADINI: No, no.

DR. LETELLIER: -- distribute the total --

MEMBER CORRADINI: Otherwise you did it randomly. You might overly bias it in one place and miss something.

DR. LETELLIER: Exactly. Because we don't, *a priori*, we don't know where the problem insulation types really are. Professional experience tells us which ones to be wary of. But we don't know what the risk dominate is. And, you can see that there are some 670 extra wells that contribute very, very little.

So, let's look at debris generation. Here's a graphic of a nested zone of influence to remind everyone that Nukon fiberglass has a prescriptive fraction by mass that's damage, as you describe, of higher potential --

DR. WALLIS: You still have Microtherm in this thing?

DR. LETELLIER: Yes.

DR. WALLIS: I thought Microtherm was a very bad thing to have.

DR. LETELLIER: But very, very little. In fact, we think it's completely gone.

MR. KEE: Well, it's not completely -- We verified that. It's --

DR. LETELLIER: Okay. So the CAD model's right?

MR. KEE: There's two products. And I always get them confused. Microtherm and --

DR. LETELLIER: Marinate.

MR. KEE: Marinate. Marinate's gone. Microtherm's still a little bit, tiny bits there.

DR. LETELLIER: We think there's less than a cubic foot residual.

MR. KEE: We've got rid of almost everything.

MEMBER CORRADINI: So, since Sanjoy brought this question up earlier, and he hasn't asked it, I get -- So, if you have less than a cubic foot of it, why not just get rid of it? Is there a dose issues with workers in an area? What's the issue?

DR. LETELLIER: Sometimes.

MR. KEE: And I believe this is right there at the nozzles, right? Or is that where it is?

MR. HARRISON: I'm Wayne Harrison from --

(Simultaneous speaking)

MR. HARRISON: I'm Wayne Harrison from STP Licensing. I believe we determined yesterday, we'll confirm this, but we believe these were replacement steam generator well. So they are adjacent to the steam generators, which have a lot of insulation, a lot of target material, all of them. So, that's where the contribution comes from.

CHAIRMAN BANERJEE: I guess the question was specifically related to the Microtherm.

MR. KEE: Yes, we need to look that up.

CHAIRMAN BANERJEE: Yes.

MR. KEE: We need to look it up, Wayne, where it is.

MR. HARRISON: We'll get that.

MR. KEE: Yes.

DR. LETELLIER: This is simply a comparison of a typical hand calculation where the spherical ZOI is centered on this specific break. This is a crossover leg, 31 inch pipe. And you can see that the spread sphere has been truncated by the presence of the concrete.

Please ignore the information notice in the middle. That simply reminds the user that there's a spatial interference between the sphere and everything else. And that's exactly what we want to know. On the right is the visualization inside of CASA that highlights all of the insulation that's inside of the ZOI.

DR. WALLIS: So, your 2700 cubic feet has been reduced here to 81, or something like that? So, originally we were told you had 2700 cubic feet of B

(Simultaneous speaking)

MR. KEE: If everything went in, right.

MR. MUNOZ: That's at this specific break. So --

DR. WALLIS: Yes. But for --

MR. MUNOZ: So this may, you know, there may be --

DR. WALLIS: Our double end ability, and much more.

MR. KEE: Well, wasn't the question if all of the insulation was failed, in that question that we were answering?

MR. MUNOZ: That was, yes --

MR. KEE: It's the 2700 cubic feet, or whatever it was.

(Simultaneous speaking)

MR. KEE: Yes. I mean, that's how much is. But, it --

CHAIRMAN BANERJEE: That was how much Nukon? Or how much --

MR. KEE: Nukon fiber. Within a particular break, it --

CHAIRMAN BANERJEE: There would be much less.

MR. KEE: -- would encompass the entire plant. It's just --

DR. WALLIS: And I thought for the worst break, the double ended guillotine break, the worst one, these joint event points was pretty well everywhere. Is that not true anymore?

DR. LETELLIER: This is one of the larger ZOIs that you'll find in the plant.

CHAIRMAN BANERJEE: This is a double ended guillotine break?

MALE PARTICIPANT: Yes, it is.

DR. LETELLIER: I apologize if I mislead

you about the maximum quantity. My calibration comes from some earlier studies where we did not clip with the concrete. I think there is a low probability tail that's a very large quantity. And we can find that for you.

CHAIRMAN BANERJEE: Anyway, in this case it's of the order of 81, right?

DR. LETELLIER: That's correct.

DR. WALLIS: You're going to reduce it to three?

DR. LETELLIER: That's the ratio at three. Yes. In some of these scenarios we're successful, and some we're not. And I'll show you why. This is, Slide 109 is just a mass comparison of volume between the hand calculation and the CASA generated values, to show you that CASA has a slight over prediction for good reasons, in the way that we've modeled the insulation.

DR. WALLIS: Well, now we've got big numbers of feet cubed. Or maybe I misread something before? You've got 264 cubic feet of fines here.

DR. LETELLIER: Well this --

DR. WALLIS: The previous slide today, one or something --

MEMBER CORRADINI: It all depends on the, I think what they're assuming is the location.

MR. MUNOZ: But this --

DR. WALLIS: The next slide is different from this one.

MR. MUNOZ: This is the same, it's the same location. So, the difference here is, to make this comparison, to be able to do the visual comparison for everyone to see in the slide show presentation, I had to compare only the Nukon.

However, in the STP evaluation we considered Nukon and ThermalWrap to have the same properties. So, on the next slide you see the addition of the Nukon and the ThermalWrap that give you your load in the fiberglass category.

DR. WALLIS: So, the double wrap is just Nukon wrapped in something, isn't it?

MR. MUNOZ: Yes.

MEMBER CORRADINI: ThermalWrap. It's a trade name.

DR. WALLIS: So, this 81 is sort of misleading. It's the next one we should look at.

MR. MUNOZ: Yes.

DR. WALLIS: So we do get much bigger numbers.

MR. MUNOZ: Yes. This is the total.

DR. LETELLIER: And here's the residual Microtherm. The CAD volume, there's still a residual quantity, a very small quantity, through the --

CHAIRMAN BANERJEE: That's quite a bit less, right, the CAD?

DR. LETELLIER: Yes. Very much less. There's, this is a ratio of small numbers, so the percent difference is artificially high. But the fact is that there's almost no --

DR. WALLIS: But the total fiber there is what, 1500 or something? It's big. It's getting near your 2700.

CHAIRMAN BANERJEE: Yes. That is getting closer to what you -- So these numbers are very different from the previous slide, right?

DR. LETELLIER: So, keep in mind that there are different trade names, there are different insulation products. And so, we're combining these two. The previous slide, 108, was for the Nukon only. And, Dominic, was it also for just one of the nested spheres?

MR. MUNOZ: That was the total ZOI for Nukon. But the reason I did that was because I was trying to show that visual comparison. And I was having trouble pulling both types together. So, giving the slide show presentation, again, that was just for visual purposes, to compare the one type.

DR. LETELLIER: You have the information you need for --

DR. WALLIS: Well, I still don't understand how you got it down to three.

DR. LETELLIER: We're getting there.

DR. WALLIS: We're getting there.

DR. LETELLIER: All right. Let's talk about coatings material. For the qualified coatings that are damaged inside of the ZOI, out of 105 pounds in the CAD, qualified epoxy in the CAD environment we applied a 4 Diameter ZOI for all epoxy coatings. And before I said that --

Please don't interpret these assumptions as being reviewed and approved. These are simply exactly what's been used in our example. Qualified zinc we have 35 pounds destroyed in a 4D ZOI. And these are fixed numbers that appear in all of our examples. In fact, these are fixed numbers in all of our break scenarios.

MR. MURRAY: So, for the recording, you

indicated 35 pounds, and it's 39 pounds on your slide.

DR. WALLIS: So, what's the size of these things when --

DR. LETELLIER: They're assumed to fail as ten micron particulates.

DR. WALLIS: All ten micron.

DR. LETELLIER: I need to look at the debris specifications.

DR. WALLIS: So, they go right through the fiberglass bed?

DR. LETELLIER: As I said, they're 100 percent filtered in the bed.

DR. WALLIS: But that's not what happens really.

DR. LETELLIER: Indeed, you're exactly right. And if we could take defensible credit for that we would.

DR. WALLIS: And yet, you don't -- A hundred percent filtered in the bed?

DR. LETELLIER: By assumption, yes.

DR. WALLIS: You mean they don't get to the core?

DR. LETELLIER: As I stressed before, we have a fiber threshold that we believe includes the effect of --

DR. WALLIS: I know what you mean.

DR. LETELLIER: -- concurrence particulate.

CHAIRMAN BANERJEE: Well, they do --

DR. WALLIS: But you told me it --

(Simultaneous speaking)

DR. WALLIS: Well, if you filter with ten micron particles you'd have thousands of psi pressure drop.

DR. LETELLIER: We can look at the attributes of the composite there, and figure that out.

DR. WALLIS: Because I use a form just like your Page 85 here for ten microns. And it doesn't take much to give you an enormous pressure drop.

DR. LETELLIER: At what maximum bed density?

DR. WALLIS: Just assume it's filled up with the particles. You know the properties of the particles. If they're spheres you can get one answer. You actually get the real --

DR. LETELLIER: So, I think we should --

DR. WALLIS: The tell you it's a different answer. But it just assumes the pores are filled up with cracked particles as high as they can go.

CHAIRMAN BANERJEE: Graham, we'll revisit the pressure loss calculations. But let's see what you guys got.

DR. LETELLIER: Unqualified coatings are a bit different. And remember that this is everything else that doesn't have a pedigree for the environment. First of all, we've already stressed that all of the damage for unqualified coatings is in the early. There's a total amount in containment. Keep that number in mind.

We're going to apply failure fractions and transport fractions. The failed epoxy is further binned in the size ranges that's suggested from EPRI testing. And this is also important, 83 percent of this amount is in the reactor cavity. And even if it fails, it cannot transport, by assumption.

Now, we could revisit any of these statements. So, in the lower containment, and this question came up before, by location how much transports? In the lower containment 100 percent is assumed to fail and transport to the pool. If the unqualified coatings reside in the upper containment only six percent is assumed to fail and transport.

That's a composite.

And this has been a source of confusion in the submittal. The six percent is actually a combination of failure mechanisms and transport mechanisms under spray. And I don't want to dwell on it now, but we're having continued conversations with the staff.

MEMBER STETKAR: It's presuming the spray is cut back when the operators cut it back, and shut off when the operators shut it off.

DR. LETELLIER: That's right. So, let's trace one of the more simplistic logic trees. This tree is evaluated just like an event tree, event sequence, by multiplying the branches.

If you start with the total inventory of 369 pounds in upper containment, assume 100 percent failure, and 83 percent is -- Where are we? In the upper containment. Six percent transport. And it's all mobile when it gets to the pool. That's the contribution from upper containment.

DR. WALLIS: The six percent came from somewhere?

DR. LETELLIER: As I said --

CHAIRMAN BANERJEE: That's still under

dispute.

DR. LETELLIER: It's under dispute. And it credits turning off the sprays, so that the material in upper containment neither is impinged in the environment, nor transports. But you can see how the math works. And this is the amount of particulate for unqualified IOZ.

MEMBER CORRADINI: What is that, the unqualified IOZ?

DR. LETELLIER: Inorganic zinc.

MEMBER CORRADINI: Oh, thank you.

DR. LETELLIER: It's a coatings product that --

MEMBER CORRADINI: All right, fine.

DR. LETELLIER: All right. Unqualified examples --

CHAIRMAN BANERJEE: Does that include galvanized zinc? Or, what is unqualified zinc? Is it zinc --

DR. LETELLIER: Galvanized?

MS. LEAVITT: No, it's a zinc paint.

CHAIRMAN BANERJEE: It's just a paint.

MS. LEAVITT: It's a paint with inorganic zinc chips in it.

CHAIRMAN BANERJEE: Okay.

MR. KEE: It acts like galvanized though, because of the zinc.

DR. LETELLIER: So the unqualified epoxies have actually been sampled. The amount that's failed is a random number. So we can't give you exact values on this equation. But you will see the inventories on the next chart.

The logic works the same, depending on its location. And it's important that we have plant data to understand where the inventory resides, so that we can make rational assumptions about --

DR. WALLIS: These numbers are the same, independent of the size of the chips?

DR. LETELLIER: Yes.

DR. WALLIS: I would think it's the fines that get transported. You just assume everything.

MR. MUNOZ: This diagram is chip size dependent. So this is just for the fines. If we were looking at the large chips or the curls, they'd each have their own dependent transport fraction tree.

DR. LETELLIER: These trees are itemized in Volume 3, if you wish to study them further. The random sampled number is, basically accounts for potential range of delamination that's sampled between 50 and 100 percent of its total.

DR. WALLIS: So only two percent of the fines get transported then?

DR. LETELLIER: Well, lower containment. This is actually the, two percent of the inventory resides in lower containment.

DR. WALLIS: Oh, only two percent is there.

DR. LETELLIER: Right.

DR. WALLIS: Okay, thank you. That's good.

DR. LETELLIER: So, we don't have to dwell on this except to take note that there's a large amount. If we sum -- The epoxy is from Line 4 to the bottom. This is 1900 pounds of epoxy alone, and then IOZ, alkyds and enamels contribute several hundred pounds additional.

So now we introduce the concept of the examples. Because we have a different brand and value for the epoxies we now have case studies, Example 1, 2 and 3. You can see that the epoxy totals are the only thing that varies, 25 pounds down to 19.7.

MEMBER CORRADINI: And, I'm sorry. You said it, but now I've lost it. Why does it vary?

DR. LETELLIER: Let's go back up here.

We've sampled the potential range in delamination.

MEMBER CORRADINI: Oh, oh. Okay.

DR. LETELLIER: Fifty and 100 percent.

MEMBER CORRADINI: All right. Thank you. So these three examples lie in the range? It's a uniform distribution?

DR. LETELLIER: Yes.

MEMBER CORRADINI: Okay.

DR. LETELLIER: So, just some summary slides. We could tell that these three examples are all from an identical large double ended guillotine break. So the fiber debris are identical for all three. But you can see how they compare by size. Latent fibers is now included. We've incorporated 12 and a half cubic feet of latent fiber in every break scenario.

DR. WALLIS: It is nothing compared with the mountains.

DR. LETELLIER: Of course. Yes, of course. But for small breaks, conversely, it can compete with the --

CHAIRMAN BANERJEE: So then it becomes more like one of our new plants, where it's all latent fiber.

DR. LETELLIER: Right. The table

identifies all of the random variables that were sampled. The time to secure a spray sim, the time for hot leg injection, the chemical product for chemical factors one can assume. The ones involved are actually important to interpreting the results that we'll see next.

DR. WALLIS: So, can you go back to how much fiber there was? Didn't you tell me it was 71 small fiber? Oh, that's generated. How much gets to the pool?

DR. LETELLIER: So this is all -- Okay. Percentage transported to the pool is on the right, correct?

MR. MUNOZ: Yes.

DR. WALLIS: So, it's 97 percent of the fines. So it's 250, what are the units here foot cube?

CHAIRMAN BANERJEE: Cubic feet.

DR. LETELLIER: Yes. On the far left it says cubic feet.

DR. WALLIS: So there's still quite a bit of fiber that gets to the screen, right?

DR. LETELLIER: Absolutely. So, yes, all of the fines and smalls are assumed to be transportable in the pool at the time of recirc.

DR. WALLIS: This is awkward. Because, you know, you talk about volume here. And you talk about grams when you get to the -- I'm trying to make a conversion.

DR. LETELLIER: Yes. The engineering conventions tend to flip flop at the board. Okay. So, you have your paper copies. You can keep the attributes straight. But we'll use a common format for all the remaining slides. Example 1 is in the upper right, Example 2 lower left, Example 3 lower right. And we'll look at various attributes of the time history.

DR. WALLIS: So, what's the source of your getting so many fibers out to the screen? This is your experiment?

DR. LETELLIER: Oh, filtering? Yes.

DR. WALLIS: Because other people get much more by product. I don't understand why you're so successful. You've still got about the same kind of a screen, same kind of hole size.

DR. LETELLIER: South Texas is the first plant that I'm aware of to actually quantify these parameters of a physical filtration model based on data.

DR. WALLIS: No. Other people have done, got data too, of by products.

DR. LETELLIER: But they may be based on --

DR. WALLIS: It's usually remarkably high.

CHAIRMAN BANERJEE: So we are just looking at bed thickness right now, right?

DR. LETELLIER: Yes. These plots are the growth of the bed over time. It's driven by the presumed pump flow. These are all trains running. So this is a maximum rate of accumulation.

The bed thickness in meters is accorded to .17 meters. Does this comport with our earlier discussions?

CHAIRMAN BANERJEE: Six inches. That's half a foot, a little bit more, right? Six inches.

DR. LETELLIER: But keep in mind that the math we were doing earlier was on a generated quantity. And you can see how it's been reduced by transport fraction.

DR. WALLIS: This is a bet thickness on the core?

DR. LETELLIER: No, on the strainer in the --

CHAIRMAN BANERJEE: Not the core, to really get it, six inches.

DR. WALLIS: But there isn't six inches

between the plates of the strainer. How can you possibly get six inches on it?

DR. LETELLIER: So, we haven't talked about this aspect. But we have a geometric loading table that presumes uniform loading. And it accounts for the transition.

DR. WALLIS: What's the space between the plates of the train?

DR. LETELLIER: One inch.

DR. WALLIS: So, you've got six inches, five inches have got to go somewhere else.

CHAIRMAN BANERJEE: Around it.

DR. LETELLIER: There's a transition in the effective area. So it continues to grow on the circumscribed shape.

CHAIRMAN BANERJEE: It begins to look like a large box.

DR. LETELLIER: Yes.

CHAIRMAN BANERJEE: Three big blocks.

DR. LETELLIER: Okay. Let me catch up with myself. Okay.

DR. WALLIS: So why do you call it a bed thickness if it isn't a bed thickness.

CHAIRMAN BANERJEE: It's not. It's just a equivalent bed thickness.

DR. LETELLIER: So, this is the outermost thickness of the bed that actually receives the debris. And it's the basis for our head loss calculation. It's, the velocities are distributed over a corresponding area. So we have an increase in velocity.

NPSH calculation should be relatively familiar. We talked about the assumption that the pressure in containment is assumed to be equal to the saturation pressure above the boiling point, 212. Below that temperature its assigned atmospheric temperature. So --

MEMBER CORRADINI: And the same thing with the negative quantity, right? So they cancel?

DR. LETELLIER: No. Well, yes. Above the boiling point they do cancel. But below the boiling point this vaporization pressure gets lower and lower. So, you gain margin.

MEMBER CORRADINI: No. I understand that. But, I mean --

CHAIRMAN BANERJEE: They are in opposite directions to each.

DR. LETELLIER: Exactly. It's the first --

MEMBER CORRADINI: But as I approached saturation, when you define saturation at 212, they balance?

DR. LETELLIER: Yes.

MEMBER CORRADINI: Okay, fine.

DR. LETELLIER: That's right. And we'll see the margin recovery in a moment. So, let me flash back. The margin is actually the available, minus the pump requirement. We have not accounted for the presence of debris. And these are traces of the margin for all three cases.

MEMBER CORRADINI: Will that -- Just go back, please? I'm sorry.

DR. LETELLIER: How much do you want to --

MEMBER CORRADINI: So, they're approximately the same in terms of the margins are with about 40 feet?

CHAIRMAN BANERJEE: They start around 25 feet.

DR. LETELLIER: Yes.

MR. MUNOZ: And there's only two lines shown on each plot, one for trains 1 and 2, and one for train 3. Train 3 differs, because when, after you reach six and a half hours we, or around six and a half hours sampled, we turn off one containment for the inside of the model. And so, you'll see that there's a slight difference in those.

DR. LETELLIER: We're actually going to revisit this graph in comparison to the total head loss too, in a couple of slides, which will kind of put it more into context of how we're doing it, the failure analysis --

DR. WALLIS: Your pumps must be pretty low below this pool. Otherwise you'd never get such a big number.

DR. LETELLIER: Yes. There's 15 to 18 feet in 12 feet.

MR. MUNOZ: Minus 11, the minus.

DR. LETELLIER: Yes. It's an atmosphere plus the elevation. That's right. We've talked at length about how the chemical formulas are applied. And these are the results.

First of all, we're looking at both the head loss, compared to buckling and the NPSH margin. The buckling limit is 9.35 feet of head for the strainer. And in most cases this is the limiting condition. We very rarely, if ever, fail on loss of margin.

Now, remember there's also a gas evolution factor. We can't exceed two percent, which is directly related to the NPSH head loss. You can see that Case Number 2, in the lower left, is actually exceeding the strainer limit. None of the others, Example 1, and Example 3 do not challenge the strainer limit.

MR. MUNOZ: Earlier we had highlighted some of the randomly sampled values. I kind of highlighted those in the top left. So, you'll see that the chemical head loss time, then the chemical head loss factor that were sampled are shown there. You can see that in this case we've had a sump failure.

So, in the lower left hand corner, yes, in the lower left hand corner you can see that we, see that the buckling limit. You can see that this exactly matches up to 405 minutes, which is shown in the second text box down. You can also see here that a high chemical head loss factor was sampled for this time.

DR. WALLIS: What does that mean, chemical head loss factor?

CHAIRMAN BANERJEE: That's the multiplier.

DR. LETELLIER: The exponential distribution. We went back to the table of attributes. We have independently sampled values that are assumed for the chemical head loss effect.

MR. KEE: It was nominally three, right, from the break?

DR. WALLIS: This isn't the factor of 24, or something you're talking about?

DR. LETELLIER: Not in this case.

(Simultaneous speaking)

CHAIRMAN BANERJEE: It says five.

DR. LETELLIER: A factor of five in Example 2.

DR. WALLIS: You're awfully precise about knowing that factor.

MR. MUNOZ: And this kind of, this really demonstrates the uncertainty that was involved in that factor, or the uncertainty that it adds. Because all three of these beds were around the same thickness. And this one fails because we, you know, randomly chose a higher chemical head loss factor. That's kind of what I was trying to point out with that.

DR. LETELLIER: The NPSH is showed in the dash lines. And the solid prediction never challenges the NPSH.

DR. WALLIS: So, where is Example 2 those? I just see two colors.

DR. LETELLIER: Example 2 is this lower right hand, lower left hand panel.

DR. WALLIS: That's supposed to be the yellowy color, isn't it?

DR. LETELLIER: This entire panel is --

DR. WALLIS: The entire panel is. Oh, all right. Scratch it.

CHAIRMAN BANERJEE: It's just the yellow chemical head loss 5.02 chemical head loss time for 105 minutes, right?

DR. LETELLIER: Yes. That's it. Almost done. Air evolution is a two percent void criteria. Just to be clear. The law applies this limit at the strainer, rather that at the pump inlet. It's both a simplification, and also a conservatism. We don't account for flow fractionation or bubble collapse, or other complications.

And you can see here, this is the two percent limit for Case 2. It's never challenged. And, in fact, the limit doesn't even appear on the others. But this is computed directly from the NPSH curves.

CHAIRMAN BANERJEE: And the, above the chemicals the head loss is calculated from your correlation?

DR. LETELLIER: That's right. As described with both compression and the factor of five. I think this -- Yes, okay. We're going to talk about the fiber penetration and the boron limit. And this is what you've been waiting for, I think. These are --

DR. WALLIS: With bated breath.

DR. LETELLIER: -- filtration efficiency. So, it's interesting to note that in Case Number 1, remember that the vertical line is the onset of recirculation. So nothing happens for 30 minutes. But the initial fiber that's applied is enough to increase the filtration to nearly 100 percent.

DR. WALLIS: That's why you are so successful. You used the fibers to filter fibers. Actually, we need to build up this big billow of fibers.

DR. LETELLIER: No, not --

DR. WALLIS: Just a little bit, just a little bit.

DR. LETELLIER: Actually, it only take a little bit. And based on the envelope of variation in these model parameters for the filtration, this is the random sample value. So, the initial quantity of latent debris, and the initial fill up phase is enough to increase efficiency to almost 100 percent.

DR. WALLIS: But this 65 percent you started with is what other plants seem to be struggling with.

DR. LETELLIER: Well, this is the clean strainer. We talked about it this morning. With no other debris present about 65 percent will be captured on the first pass.

DR. WALLIS: If you make the strainer bigger, and bigger, and bigger, you'll get even more than that.

DR. LETELLIER: This is scaled to the strainer area.

DR. WALLIS: Yes. But if you make it bigger you get more of that. Because you have to build up a certain layer to filter the other.

DR. LETELLIER: True.

DR. WALLIS: Right.

DR. LETELLIER: That's true.

DR. WALLIS: So, it's a --

DR. LETELLIER: But in the case of Example 2, the initial amount of fiberglass was not enough to reach 100 percent efficiency. And this margin here will lead to failure.

MEMBER CORRADINI: I think I understand

the --

MR. MUNOZ: Actually, it's this one.

DR. LETELLIER: It's this one.

MEMBER CORRADINI: Well, I'm trying to -- So, now the colors matter. So, if I go to the orange, what do you mean by sump failure. I didn't understand that.

MR. MUNOZ: So that example case was a sump failure. So, previously where we exceeded the buckling limit with the --

MEMBER CORRADINI: Oh.

MR. MUNOZ: -- head loss, we're just carrying all three examples all the way through.

MEMBER CORRADINI: Yes. I understand that.

MR. MUNOZ: And kind of see through --

MEMBER CORRADINI: So in this case, you were sucking on it so much you bent the strainer?

MR. MUNOZ: Yes.

DR. LETELLIER: Yes.

MEMBER CORRADINI: Oh, okay.

MR. MUNOZ: Now, remember --

CHAIRMAN BANERJEE: Due to the high chemical effects, the pressure loss was greater.

MEMBER CORRADINI: Oh, the high chemical effects. Oh.

DR. LETELLIER: The strainer limit is only 9.3 feet. So we acknowledge there's design engineering safety factors. But we call this a threshold of concern. If you challenge the threshold you fail the scenario.

MEMBER CORRADINI: So, can I just go back to that? You said this. And I just didn't catch it. So, for this one, the five times of chemical head loss was still physical? That is, you cooled it enough that you got precipitation, and the five times increase is physically reasonable?

CHAIRMAN BANERJEE: Well, any, if you suddenly get a chemical effect it can be very large.

MEMBER CORRADINI: I understand that. But I'm still back to the kind of, with all due respect, the strange looking curve. And I'm asking, have you sampled in the curve somewhere where it's not physical? And your answer is no, it's still physical that I can up it because I cooled it enough, and I had precipitation. I'm just trying to do a sanity check on that orange line.

CHAIRMAN BANERJEE: That model can be as

high as 25, or something.

MEMBER CORRADINI: I know. Okay. I just want to make sure that makes sense. I'm looking at -- You're the one that worried about this. But I'm just, I didn't catch if there was a --

CHAIRMAN BANERJEE: But if you get chemical effects it can be enormous.

MEMBER CORRADINI: Okay.

DR. WALLIS: I don't see how chemical effects would -- You have this great billowing cloud of fibers. I might see the chemicals get all diluted in the fibers, don't they?

DR. LETELLIER: Well, it depends --

CHAIRMAN BANERJEE: That's a strange effect. Because generally the chemical effects has been what's in fiber, where you get this enormous --

DR. LETELLIER: If they occur concurrently you might be right. And in fact, by analysis we're sort of imposing this concurrence. If you notice, the spike occurs at less than ten hours. Because that's the point at which we hit the 140 degrees.

We're assuming that the full effect of chemicals happened at this time point. Generally you think of chemical effects as a longer term, especially for the South Texas trisodium phosphor in the environment.

MEMBER CORRADINI: Okay. I'm still in sanity check mode. All these are about six and a half inches of thing. Because in less than an hour, in the orange line on Slide 117, I have six and a half inches of bed thickness, which is the same as the blue, which is the same as the red.

DR. LETELLIER: Yes. They're all the same.

MEMBER CORRADINI: And I multiply that by five, and I fail. So, my question back to sanity check time, is it reasonable? I'm just --

CHAIRMAN BANERJEE: It would be unusual to have chemical --

MEMBER CORRADINI: Okay.

CHAIRMAN BANERJEE: -- effects in such a strange scenario.

MEMBER CORRADINI: Right.

CHAIRMAN BANERJEE: I mean, you expect --

MEMBER CORRADINI: But I understand now why the orange fails.

DR. LETELLIER: Yes.

CHAIRMAN BANERJEE: Yes.

DR. LETELLIER: And it's here on this --

CHAIRMAN BANERJEE: It's their way of doing the analysis. I mean, it's unlikely that with a bed like this you'd get chemical effects. But that's part of your parametric study, or something, right?

(Simultaneous speaking)

DR. LETELLIER: Right. As I said, as Janet described, it's very unlikely that, and Kerry as well, it's very unlikely that we will see chemical effects, severe chemical effects at South Texas. But it's not impossible.

CHAIRMAN BANERJEE: Not on your strainers. You might see them in the core. The chemicals might get carried in somehow. Who knows.

DR. LETELLIER: If we see it anywhere, then they'll be in both locations.

CHAIRMAN BANERJEE: The problem is more, I think, what Mike and I are all concerned about is that when you have small breaks, and you have very thin layers of stuff on this, that you might get more bypass and chemicals going through, stuff like that. But your large break looks like --

DR. WALLIS: You've got the same of particles too. You're in trouble if they fill up that

--

CHAIRMAN BANERJEE: Yes. There's different phenomena. Nonetheless, we really are just trying to follow what you did. So let's move on.

MEMBER CORRADINI: So, on 125, just, I mean, finally two examples -- I'm awake now.

I'm trying to understand what made it go up from 80 percent to 100 percent filtration efficiency in 30 minutes.

CHAIRMAN BANERJEE: Because your bed built up.

MEMBER CORRADINI: No. The bed is flat as a pancake. Seven slides ago it's flat as a pancake. So why --

CHAIRMAN BANERJEE: It takes like five minute, a few hours to build up and --

DR. LETELLIER: You notice the time scale. Because nothing happens until recirc at 30 minutes.

(Off microphone comments)

DR. LETELLIER: In Slide 125 --

MEMBER CORRADINI: Okay.

DR. LETELLIER: And so, in the lower right, Example 3, you can see --

CHAIRMAN BANERJEE: Different scales.

DR. LETELLIER: At the time of recirc you start to ingest the local concentration. And that's what increases the efficiency.

MEMBER CORRADINI: Yes, but -- Okay. So maybe I've missed the connection.

CHAIRMAN BANERJEE: Why don't you accept that this is part of the correlation that they have?

MEMBER CORRADINI: I don't. I'm sorry.

CHAIRMAN BANERJEE: Well, if you don't like the correlation --

MEMBER CORRADINI: I'm just trying to get back to -- Because everything on Slide 117 is essentially the same thickness.

MR. MUNOZ: So there is --

MEMBER CORRADINI: And I'm just trying to understand why, with the same thickness, the filtration efficiency is different. That's what I'm asking.

CHAIRMAN BANERJEE: It's 30 minutes.

DR. WALLIS: Different time.

MEMBER CORRADINI: No.

MR. MUNOZ: And at the beginning of the example we had looked at sample parameters for the shutting -- Can we just go back to that, Bruce?

DR. LETELLIER: Real quick. Let's just --

MR. MUNOZ: That's hours.

DR. LETELLIER: -- make it clear, this is in hours.

MEMBER CORRADINI: They're all the same.

DR. LETELLIER: Yes, they are. But they're in a much longer time scale. So, 30 minutes, it doesn't really start to build a bed until recirculation at 30 minutes. Now, let's jump ahead to 125.

MR. MUNOZ: I was just pointing out that we have different randomly sampled factors that affect the shedding.

MEMBER CORRADINI: Okay, fine.

MR. MUNOZ: And that's what --

MEMBER CORRADINI: So, something's there between Slide 117 and 125 --

DR. WALLIS: So, Mike, if you look at the scale, a half an hour, there's nothing on 117 at all.

MEMBER CORRADINI: But if I took -- I'm sorry to be hard headed. But if I took 117 and I overlaid all three slides, they would look identical in the first 30 minutes.

CHAIRMAN BANERJEE: Because the scale is too small.

DR. WALLIS: Nothing happens in 30 minutes --

MEMBER CORRADINI: They're the same. It's something between 117 and 125 that makes the difference.

CHAIRMAN BANERJEE: Okay. We'll table that question. Let's go on.

DR. LETELLIER: So, we're going to look at the failure, so we understand how the failure, I'm sorry, how the filtration behaves. At the moment of recirculation, in the first five minutes, which is only one time step in our integration scheme, we've improved the efficiency from 80 percent to 100 percent.

Now, that should raise some questions. I mean, there's a sensitivity there. There's an opportunity. So, we understand that at each time step fibers deposit on the core. And with the cumulative it's constantly added together. So now, within five minutes we've shut the door. We don't want to allow any more fiber --

DR. WALLIS: Are your relying on the long fibers to sort of build up this big thing and filter them? If the big fibers all settle out in the pool, what do you call these tiny things, they'll go right through the strainer, won't they?

CHAIRMAN BANERJEE: But they'll be shedding. It will continue to shed.

DR. LETELLIER: it will shed. And back to your original point this morning, our parameters are calibrated to a degree preparation that we introduce to our flume. And that's the way they behave.

DR. WALLIS: You assume that all the fibers of all lengths arrive at the same time?

DR. LETELLIER: The test protocol is well mixed.

DR. WALLIS: Yes. And none of the big ones filter out before they get there? Okay.

DR. LETELLIER: They all arrive at the same time.

CHAIRMAN BANERJEE: Mister --

DR. LETELLIER: And it's a once through test.

CHAIRMAN BANERJEE: You mean for the core?

DR. LETELLIER: So you capture -- Excuse me?

CHAIRMAN BANERJEE: Down the core blockers? What are we talking about? What tests are we talking about now.

DR. LETELLIER: We're talking about a test in the flume that was conducted for the purpose of fiber penetration tests.

CHAIRMAN BANERJEE: Okay.

DR. LETELLIER: It's a once through test. It's 100 percent downstream filtered, so that we can fractionate the quantities that pass through as a function of mass on the bed. That's the basis for filtration.

So, last slide is, let's look at the quantity fiber per fuel assembly for the three examples. And lower right, Example 3, actually exceeds the threshold of seven and a half grams. That very first time step, when the filtration was low, that first time step was enough to cross the line.

MEMBER CORRADINI: So, can you go back to slide --

DR. LETELLIER: Yes.

MEMBER CORRADINI: To 120, 125, two slides. So, I'm sitting for 30 minutes at a filtration of 80 percent. And then something happens at 30 minutes. The filtration goes up. And it grows from not a problem to a total problem. What's happening in the calculation?

DR. LETELLIER: Yes. We turned the pumps on at the vertical line. That's when recirculation happens. The debris begins to migrate.

MEMBER CORRADINI: So, you're basically moving it all through the stream?

DR. LETELLIER: Yes. And depending on your perspective, this increase is actually a good thing. The filtration effectiveness changes from only 80 percent to up to 100 percent effectiveness.

DR. WALLIS: Why is the filtration at all before you turn the pumps on?

MR. KEE: We misspoke too.

DR. LETELLIER: It's simply a constant.

DR. WALLIS: Well when --

MR. KEE: The pumps are running the whole time. There's a plant state that was defined. And the pumps are running the whole time for this Case 1. As John said, they're all, it's all equipment starts and runs.

But at roughly 30 minutes, remember the refueling water storage tank becomes empty. Now you have to recirculate the water from the containment sump. So that's --

(Simultaneous speaking)

MEMBER STETKAR: One minute they're injecting, them they start sucking from the sump at 30 minutes.

MR. KEE: Then that --

DR. WALLIS: Why don't the strainers get stuff on them before you turn on recirculation?

DR. LETELLIER: Because of the fill up phase. During, when the pool grows from nothing to its maximum depth there's an initial transport of latent fiber, some fraction, and also some of the early arrival.

DR. WALLIS: Why is that? Because water goes through the strainer?

MR. KEE: The big sump we refer to underneath the strainers has --

DR. WALLIS: Another sump?

MR. KEE: Well it's just a cavity.

DR. LETELLIER: It's just a cavity.

DR. WALLIS: And so the details are important.

MR. KEE: That's what, we mentioned that. That's why we were talking about that, the F fill, remember when we, very early this morning? Of course, that was a long time ago.

MR. MUNOZ: So they actually use standard AI, 04/07 methodology for that fill up phase. It's usually a comparison of the sump volume --

DR. WALLIS: Now I understand, yes.

MR. MUNOZ: -- of the total volume of the pool.

DR. LETELLIER: It's an attractive potential during the sheet flow, where it carries debris towards the strainer.

CHAIRMAN BANERJEE: I think we should -- We understand what's happening, really, in your calculations. So --

MEMBER LOWERY: I want to just --

CHAIRMAN BANERJEE: One thing I just wanted to understand more is why there is no shedding here. Why don't you keep --

DR. LETELLIER: So, you'll see it in the very, yes, in the last slide, okay. So, we're looking at accumulation on the core. And over a longer time frame of many tens of hours, you can see the effect of shedding. It's a much lower rate constant.

DR. WALLIS: What is shedding?

DR. LETELLIER: Shedding is release, continued release of fiberglass from a pre-existing bed as it migrates or releases fiber.

CHAIRMAN BANERJEE: This flow going through the beds --

DR. LETELLIER: So it's --

CHAIRMAN BANERJEE: -- takes some stuff. There's never 100 percent.

DR. WALLIS: Possible. But I would think it would die as soon as you get enough big fibers on the holes. Nothing more --

CHAIRMAN BANERJEE: You got fine fibers going through. That's the problem. The fine fibers will go through. Whatever is not full size.

DR. LETELLIER: You can read more about the simmed model in the penetration test report. We've limited the total amount to a maximum fraction of sheddible fiberglass. As you say, it's only the small material. And it's roughly three percent of these initial mixture. So that, I did want to say something about potential sensitivity. Because --

CHAIRMAN BANERJEE: So, why does this sort of flatten? Why doesn't it -- To me it would seem that it would accumulate over a long period of time. This would just keep going up due to shedding.

DR. LETELLIER: On these time scales the

shedding is limited to about three percent. And over 30 hours of the calculation it's almost flat.

DR. WALLIS: Three percent is a lot of big billowing --

MEMBER SCHULTZ: I don't see it happening at all.

DR. LETELLIER: But the rate is very slow.

CHAIRMAN BANERJEE: Yes, it doesn't seem to happen --

DR. LETELLIER: The rate is slow. And it was a challenge to optimize our model against the data that we had available.

CHAIRMAN BANERJEE: Okay. That's some point we can take up. Let's --

DR. LETELLIER: Just one quick, one last closing comment is that the sensitivity of our failure has been noted under review by Southwest Research. And they pointed us towards a potential problem with the time resolution for the numerical integration.

Now, we've revisited that. And we don't have identical findings as they do. We're successful. We're able to reduce the time step from ten minutes to five minutes, down to a tenth of a minute, to a hundredth of a minute. And we see good convergence. We see normal smooth behavior of different resolution. So, there's an outstanding issue that we need to --

CHAIRMAN BANERJEE: What did they find?

DR. LETELLIER: Well, the staff can speak. But they found an increase in failure probability with a decrease in time step. And they pointed us towards the core failures in particular. So, we'll define a case study and chase this to resolution.

CHAIRMAN BANERJEE: So, I have a question here, which is somewhat important to the chemical business. Did you do the same with the penetration model? Did you have some probability distribution of what passes through? Or, did you take that into consideration?

DR. LETELLIER: We sampled the envelope of two key parameters, which are the time constants and the rate of growth for filtration.

CHAIRMAN BANERJEE: But not the amount going through?

DR. LETELLIER: That's calculated based on the model.

CHAIRMAN BANERJEE: On the model.

DR. LETELLIER: The equation. We set up the parameters, evaluated the equation.

CHAIRMAN BANERJEE: So, how uncertain is the calculation of what's going through the, penetrating through the, I mean, is it plus or minus 50 percent, or 100 percent, or 300 percent? I mean, with the chemicals you took this uncertainty into account for this multiplier of some sort. Do you have a multiplier for the fiber going through?

DR. LETELLIER: We could calculate a multiplier, which we have not, because we're actually simulating this as a physics process. We have data, we've calibrated the parameters, and we're calculating the resulting penetration.

CHAIRMAN BANERJEE: Yes. But your model could be wrong.

DR. LETELLIER: Indeed. But it's consistent with the data that we have. And we're sampling over the full range of the parameter very --

CHAIRMAN BANERJEE: So you haven't done to, I mean, essentially the chemical effect is a way to say that my model, my pressure losses has uncertainties. So, I'm going to distribute that uncertainty in some way, give it a factor of 25 maybe, which seems quite reasonable to me, knowing what happens with these beds. But you didn't do that to the penetration model, from what I understand right now. Okay. Let's move on then.

DR. LETELLIER: We are essentially finished.

CHAIRMAN BANERJEE: Wow. Fantastic.

DR. LETELLIER: I have some closing statements about --

CHAIRMAN BANERJEE: Is --

DR. LETELLIER: -- what we've learned today.

CHAIRMAN BANERJEE: But be quick.

MEMBER STETKAR: Now you're heard.

(Simultaneous speaking)

DR. WALLIS: And so you are really at the same level as a plant which had far less fiberglass. Because the penetration all happens at the beginning. And all the extra fiberglass has built up a big mountain and stopped. It doesn't contribute to the core at all.

CHAIRMAN BANERJEE: Okay. Let's --

DR. WALLIS: And so if a plant which had, you know, one percent of this amount of fiber would be about the same in the first half hour.

CHAIRMAN BANERJEE: That's a great observation. But I'm going to have to stop --

DR. WALLIS: But isn't that true? And that's why --

CHAIRMAN BANERJEE: Can you please make your closing remarks, Mike and Bruce? And then --

(Simultaneous speaking)

CHAIRMAN BANERJEE: I'm going to ask for public comment after that. And then we close. We will sequester.

DR. LETELLIER: So, if you get your arms around the body of work that South Texas has accomplished you'll recognize that models all the way from RELAP to the filtration models, to this to correlation or modified head loss, it had really been essential to gain subtle insights into the way the plant performance, and what's driving risk.

There's some work that remains regarding codings, and how we come to a disposition of a head loss correlation. But there are active steps forward that we can take. We developed a couple of tools from RISKMAN and CASA Grande that are now mature enough to wrap it into an assessment.

We can study parameter uncertainty, model uncertainty, by changing out models. We've done risk quantification with uncertainties actually. And now we can do risk attribution, so that we can pull the thread and look at potential mitigation actions. Just a final reminder that our risk metrics of CDF, LERF, Delta CDF, Delta LERF, they're small. They're well within Region III. And we really don't expect the resolution of these issues to change that result.

CHAIRMAN BANERJEE: So, thank you. And, I think what I'd like to do is to ask if there are any members of the public who would like to make --

MR. MURRAY: Just a couple of closing comments from me, if you don't mind.

CHAIRMAN BANERJEE: Oh, okay. Sorry.

MR. MURRAY: Please.

CHAIRMAN BANERJEE: I missed that.

MR. MURRAY: So, one, I want to go over the meeting purpose. And I'll be very brief. We reviewed the changes, which was the purpose. We described the risk and of course treatment of debris. And what we tried to do is show how we had treated it through the application. And provide specific examples.

Have we met those desired outcomes at ACRS? Whether we have answered every detailed question, overall, do you have a better understanding of how we treated this is my basic question.

CHAIRMAN BANERJEE: Yes. I think what we do, Mike, is after I take the public comments --

MR. MURRAY: Right.

CHAIRMAN BANERJEE: And before we go into closed session, I'll ask the members to give a quick overview, and our consultant as to what they saw in this meeting, their comments. And then we'll go into closed session just for informational purposes.

MR. MURRAY: And that shouldn't take long.

CHAIRMAN BANERJEE: That shouldn't take long.

MR. MURRAY: And we can push on.

CHAIRMAN BANERJEE: And we'll close the meeting.

MR. MURRAY: So, the last comment I have is, we really appreciate the opportunity to sit down. And your time to listen to what was done in the application was very much appreciated. And also, we continue to work with the staff to resolve, reconcile questions that are similar to some of the ones you had asked you had asked us today. So, we're continuing to stay engaged with the staff in the review process.

CHAIRMAN BANERJEE: We certainly understand this is work in progress. So, now I'd like to ask if there are any members of the public who would like to -- There's nobody, at least in this hall, who would like to make one?

MR. LEWIS: Yes. My name's Marvin Lewis.

CHAIRMAN BANERJEE: Okay.

MR. LEWIS: Look, this is outside the scope I believe of this meeting. But it relates to it. From the NUREGs and the SECYs that I've read, they state that the, they state originally that the design must be mechanistically evaluated. And that the PRA is a complement that evaluates.

And I'm just wondering, from what you said here it seems that these two things were almost unrelated. And I'm just trying to figure out, where is my mistake?

CHAIRMAN BANERJEE: Well, is that your comment? We'll certainly take it into account.

MR. LEWIS: That's my comment. Thank you very much.

CHAIRMAN BANERJEE: Thank you very much. Are there any other comments from the public? So, if not, I'll now ask the members of the subcommittee to make their own very brief comments, please. So, I'll start with Graham, and --

DR. WALLIS: Well, what you're trying to do makes a lot of sense, to try to be much more realistic about what really happens. And the questions which remain, which are big ones, can you predict these things?

Because we have learned over many years of studying this that really you couldn't predict what was going to happen when you did these tests. And the head loss was always a surprise. And now you're coming back and saying, we know how to predict it.

So, you have to somehow convince us that you can really predict, with the proper number of tests, enough variation of things, and enough checking that your methods really work. And we haven't seen that yet. I think that's what we need to see.

CHAIRMAN BANERJEE: Okay.

DR. WALLIS: But the overall objective, and the scheme of things, if you can really do it, is an ambitious and reasonable thing to do.

CHAIRMAN BANERJEE: Okay. Thank you. Steve.

MEMBER SCHULTZ: I agree with Graham's comments with respect to your question, Mike. To me you accomplished your objectives. What has been presented today certainly give me a much better understanding of how the overall process fits together.

The staff has taken on, you have taken on, as Graham has indicated, a large challenge. And the staff has responded accordingly, based on the current state of the RAIs, both in terms of their questions and your answers. So, there's a lot more information to integrate. And that's the challenge for you, and it will be for the committee as well.

CHAIRMAN BANERJEE: Thanks. Harold?

MEMBER RAY: Yes. I won't add anything. This is impressive, daunting, different adjectives come to mind, but worthwhile.

CHAIRMAN BANERJEE: Thank you. Dennis?

MEMBER BLEY: Yes.

CHAIRMAN BANERJEE: But you speak for our --

MEMBER BLEY: I can speak a little bit for our esteemed colleague. You're whispering something. First, I'd -- Save Mike that time. We don't speak for the ACRS except in our full committee letters. So, you aren't getting an expression of the ACRS, you're getting individual thoughts.

DR. LETELLIER: Understand.

MEMBER BLEY: For me this was very, very helpful. I've been waiting to see somebody try this. I'm really glad they're doing it. Now you've given me a bit of a road map, so I can really dig in and try to figure out enough so that I have a knowledgeable, technical opinion about what you've done.

I'm a little uncomfortable with some of the areas. And it's related to what's going on. You know, prediction may not be the gain. But what it needs to do is, within the uncertainty analysis consider the full range of possibilities, so that we're convinced we've covered the problem, and we kind of have the best though of the technical community, and the probabilistic results that come out.

There are some areas, factor of five here, standard mix of stuff there. And I'm not thinking about particle like those. There's a bunch of places that really affect the outcome. And I've really got to closely to see if I think you've covered those well. Some of them seem kind of arbitrary. And it's a complex thing. So, I don't know how much they affect the results.

So, I think it takes a lot of care to make sure we're, that the probabilistic answer is really addressing all of the uncertainties that matter, in a way that makes sense. And it's going to take, on my part, a lot more work to see what you've done.

But some of the stuff we heard makes me think there are spots where you need to be a little more careful. And Graham's comment is really on target. Every time we'd see one of these tests, and they go do another, yes, that ought to tell us what we want. Oh, went the wrong way. That takes a lot of uncertainty band to cover that.

And it feels where, I don't know if we're a little over confident. That's kind of the sense I get, that we might be a little over confident in the way we're handling some of the uncertainties in the models. That's a lot more John's. I think that really gets to the heart of the things he's been worried about as well.

Some of your answers for his questions helped him see that. I think he got a better feel that what you're doing makes than what we thought we were at. And I wish what you wrote was as good as what you said. Go ahead.

CHAIRMAN BANERJEE: Joy.

MEMBER REMPE: I don't have anything significant to add, other than I do appreciate the effort that you've made to come here with a very lengthy and detailed presentation. And as we move forward, and go and address some of the individual issues, it will be also very helpful to us.

CHAIRMAN BANERJEE: Mike.

MEMBER CORRADINI: So, I think we really should thank you for what you've done. It's been two years and three months since we last, since the last time I thought about this. So, it's a while. I do think that you've done a lot. I do think though, how you present it could benefit from some reversal of how you do it.

All the specific examples, it wouldn't hurt to take one of them, and start the whole thing off by walking through a calculation, from a big picture standpoint. I think Graham asked, as he is wont to, a few questions to kind of start us off in that direction.

But it seems to me, if it's another two and half years before we see you, we're going to forget. So, my suggestions is, start of one of these things -- Because it's such an integrated calculation and estimate. To just walk us through it, so we see how all the pieces fit together. And you can hold us off, and then come back and talk about each of the individual pieces.

I think the one big individual piece that Sanjoy identified, that you are going to come back to us, or point us where to read, is how your model VISTA, I think you called it VISTA, does a better job than the 6229 or 6224 NUREGs suggests that base model.

But that, combined with how it essentially all fits together, I think is really what we'll have to be reminded next time we see it. Otherwise we're going to kind of flail away for awhile again. And the only other thing that I'm curious about, I'm still with these curves, back to the examples, as back to Graham's point about -- You said an absolutely clean containment.

But I'd be very curious to run your model to see. It's not perfectly clean, but it's -- What if you removed all the Nukon, and your model is so good? What would it predict in terms of the efficiency and the carry through to the core, versus essentially, we'll call it the Nukon plant? You took the two extremes, perfectly clean, and what you guys have here.

But if the model is supposedly useful, if I were to magically tomorrow turn South Texas into something that you removed it all, then a lot of your questions could be asked in terms of the what ifs about what the filtration is by the very fact you didn't have all the stuff there to hold it back. So, that would be another what if calculation that would be very interesting to look at, given it's an integrated assessment. So, that's it.

CHAIRMAN BANERJEE: Thanks. So let me add my thanks to a very interesting and well presented set of presentations. And thank you for taking the time for coming out. I think, from the, you know, I don't need to make any really specific comments.

But you've got the idea of the issues from the conversation we've had today, that we are likely to be interested, and all. So, the transcripts will certainly tell you that.

One of the things that might help us, as Mike said, you walked us through the large break scenario. But one of the areas that we'd be quite interested, I think, is looking at a smaller break scenario, one which is more likely. Because these large break scenarios are not going to give you very much risk anyway, because they happen so infrequently.

Even though you say they are the major contributor to the risk, the only contributor. But if you take a small break scenario, it could be that you get more stuff going through. Because you simply don't cover the filters with material, you know. And I don't know. I mean, that's the worry we've always had about increasing the area of the filters.

If you look back at our letters we said, you know, increasing the area of the filters is great to, you know, reduce the pressure losses. But more stuff is going to go through. And what you end up having is your core now acting as the filter, okay. So, it's not obvious to me at least, and this is personal opinion here, that the smaller breaks, that there could be a break size which will pose a problem.

And it could be fairly sensitive to the assumptions you've made for the various correlations and things that you use. I don't have a feel for this right now. But, if you walked us through one of those scenarios sometime in the future when you come back, that would be helpful to explain why that doesn't have a problem.

We, of course, now are going to -- What's the schedule? We're going to probably wait for the staff to come up with NSC, right, before we see you again. Or is there --

MR. BANKS: Next meeting is in March.

CHAIRMAN BANERJEE: And that's with NSC? Or that's still informational?

MR. BANKS: Part. It will be half staff --

CHAIRMAN BANERJEE: Okay.

MR. BANKS: And half STP.

CHAIRMAN BANERJEE: So, at that point, of course, it would be very valuable to walk us through a scenario like that. Because there is a suspicion that a lot of material gets through when you don't have this very effective filtering. And we don't know what assumptions have gone in and, you know, on that.

MEMBER REMPE: Actually, having a list of questions raised during the meeting, and having them answered would be a useful thing to do, just to keep the train of thought going.

CHAIRMAN BANERJEE: Yes. And you've got a lot of valuable feedback from the committee. And we've learned a lot from you today. What we've seen is a very systematic approach that you're taking. And, you know, we didn't know exactly what was going on. We know a lot more now. And it seems very, you know, you're on the right track. So we also wish you success in this, you know. It would be a nice way to be able to deal with this problem. Okay.

So, with that, I think I'd like to close the meeting, just for informational purposes. We have no other remarks to make, other than that I think, right? Okay. So we will turn it over to you, Mike and Mark.

(Whereupon, the meeting in the above-entitled matter went out of open session at 6:07 p.m. to enter into closed session.)

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

ACRS Subcommittee Meeting

NRC Staff Review Status of South Texas Project Risk-Informed Approach for Resolution to Generic Safety Issue - 191

September 3, 2014

Opening Remarks

Michael T. Markley

Acting Deputy Director
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Introduction

Balwant K. Singal

Senior Project Manager
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Options to Resolve GSI-191

In SECY-12-093, NRC Staff recommended three options to resolve GSI-191:

– **Option 1**: Compliance with 10 CFR 50.46 based on approved models.

– **Option 2**: Mitigative and alternative measures approach, including risk-informed approach.

– **Option 3**: Different regulatory treatment for suction strainer and in-vessel effects.

STPNOC Proposed Approach

South Texas Project (STP) Nuclear Operating Company (STPNOC) chose to pursue **Option 2** by adopting Risk-Informed approach for STP as a pilot plant.

NRC Staff had 18 pre-licensing public meetings with STPNOC between February 2011 and December 2012 to discuss various technical topics associated with risk-informed approach to resolution of GSI-191.

STPNOC Submittals for GSI-191 Resolution

Exemption request for risk-informed approach (Jan. 31, 2013; ML13043A013).

Revised exemption request and license amendment request (June 19, 2013; ML131750250).

Revised submittal in its entirety to correct self-identified errors (Nov. 13, 2013; ML13323A128).

STPNOC Submittals

The June 19, 2013 revised submittal included:

- A **License Amendment Request** for change of licensing basis for STP Units 1 and 2 (UFSAR Change).
- **Exemptions** from certain requirements:
  - 10 CFR 50.46(b)(5), "Long-Term Cooling"
  - GDC Criterion 35, "Emergency Core Cooling"
  - GDC Criterion 38, "Containment Heat Removal"
  - GDC Criterion 41, "Containment Atmosphere Cleanup"

NRC Technical Review

Complex technical review requires involvement of:

- Safety Issue Resolution Branch (SSIB)
- Reactor Systems Branch (SRXB)
- Nuclear Performance and Code Review Branch (SNPB)
- Balance-of-Plant Branch (SBPB)
- Containment and Ventilation Branch (SCVB)
- Technical Specification Branch (STSB)
- PRA Licensing Branch (APLA)
- Radiation Protection and Consequence Branch (ARCB)
- PRA Operations and Human Factors Branch (AHPB)
- Steam Generator Tube Integrity and Chemical Engineering Branch (ESGB)
- Mechanical and Civil Engineering Branch (EMCB)
- Component Performance, Non-Destructive Examination and Testing Branch (CPNB)
- Environmental Review and Guidance Update Branch (RERB)

Requests for Additional Information

RAIs issued by NRC (April 15, 2014) (ML14087A075) identified significant technical issues:

- Use of NUREG CR-6224 for determining head loss correlation
- Treatment of chemical effects and coatings
- Debris generation and transport
- Containment Accident Sequence Stochastic Analysis (CASA) Grande interface with the PRA
- Treatment of uncertainties
- In-Vessel effects
- Loss-of-Coolant Accident (LOCA) Size/Frequency

STPNOC provided responses to RAIs:

- May 22, 2014; ML14149A439
- June 25, 2014; ML14178A467
- July 15, 2014; ML14202A045

Status and Schedule

NRC held public meeting with STPNOC on August 20, 2014:

– Discussed NRC questions and concerns with STPNOC response to the RAIs
– Discussed current status of NRC staff review of application
– STPNOC plans to supplement RAI responses based on NRC staff questions and concerns discussed during public meeting

NRC Staff communicated plans to conduct a technical audit:

– Tentatively scheduled for week of September 15, 2014
– Based on results of technical audit, NRC staff may issue another round of RAIs

Schedule Expectations

The NRC staff expects the following meetings in 2015:

- 2 additional ACRS sub-committee meetings
- Followed by a full committee meeting

The NRC staff expects to complete the review of the license amendment request and exemption requests by **December 31, 2015**.

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Timeline

02/11-12/12:
18 pre-licensing public meetings

01/31/13:
Submitted exemption request

06/19/13:
Submitted revised exemption request and LAR

11/13/13:
Submitted revised exemption request and LAR

04/15/14:
NRC issues RAIs

05/22/14:
STPNOC RAI Response #1

06/25/14:
STPNOC RAI Response #2

07/15/14:
STPNOC RAI Response #3

08/20/14:
Public Meeting with STPNOC

2015:
ACRS sub and full committee meetings

12/31/15:
Complete review of exemption request and LAR

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Questions?

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Tie Between STP Pilot and 10 CFR 50.46c Proposed Rule

September 3, 2014

10 CFR 50.46c Rulemaking Purpose

- Revise emergency core cooling system (ECCS) acceptance criteria to reflect recent research findings
- Replace prescriptive analytical requirements with performance-based requirements
- Expand applicability to all fuel designs and cladding materials
- Address concerns raised in two petitions for rulemaking (PRMs): PRM-50-71 and PRM-50-84
- Allow an alternative risk-informed approach to evaluate the effects of debris on long-term cooling

Tie Between STP Pilot and 50.46c Proposed Rule

- SRM-SECY-12-0034, “Proposed Rulemaking – 10 CFR 50.46c: Emergency Core Cooling System Performance During Loss of Coolant Accidents (RIN 3150-AH42)” dated January 7, 2013
  - *10 CFR 50.46c proposed rule should contain a provision allowing NRC licensees, on a case-by-case basis, to use risk-informed alternatives without an exemption request.*
- 50.46c proposed rule contains high-level language that would allow licensee to use **alternative risk-informed approach to evaluate the effects of debris for long term cooling (LTC)**
  - Consistent with principles in RG 1.174
- SRM-COMSECY-13-0006 allowed 50.46c proposed rule to be published before risk-informed guidance

Rulemaking Timeline

- Advance Notice of Proposed Rulemaking Published August 13, 2009 (74 FR 40765)
- Proposed rule presented to the ACRS on January 19, 2012
- Proposed rule provided to the Commission in March 2012
- SRM-SECY-12-0034 issued on January 7, 2013
- Series of public meetings to facilitate public comments in April – July 2013
- 150-day public comment period closed on August 21, 2014

Next Steps

- Address public comments
- ACRS Subcommittee Meeting December 2, 2014
  - Status update; no letter at this time
- Develop final rule
  - Due to the Commission in February 2016 (per SRM-COMSECY-13-0006)
- In parallel:
  - Develop implementation guidance for the risk-informed treatment of debris on long term core cooling

Alternate Approach

- Alternative to STP risk-informed pilot methodology
- Scalable to use deterministic methods to the extent possible
- Risk based on pipe break frequency and size and the amount of debris generated
- Generally use staff approved methods for:
  - Debris Generation
  - Transport
  - Coatings
  - Chemical Effects
  - Head Loss
  - In-vessel Debris Limits (testing ongoing – new topical report)
- Debris limit based on testing or an agreed upon minimum to ensure acceptable head loss

References

- SECY-12-0034, “Proposed Rulemaking – 10 CFR 50.46c: Emergency Core Cooling System Performance During Loss of Coolant Accidents (RIN 3150-AH42) (ADAMS Accession No. ML112520186)
- SRM-SECY-12-0034, January 7, 2013 (ADAMS Accession No. ML13007A478)
- Advisory Committee on Reactor Safeguards on January 19, 2012 Transcript available in ADAMS under Accession No. ML12032A048
- Public meetings Summaries
  - April 29-30, 2014 ADAMS Accession No. ML14128A076
  - June 24-26, 2014 ADAMS Accession No. ML14177A048
  - July 23, 2014 ADAMS Accession No. ML14204A265

South Texas Project Risk-Informed Approach to Generic Safety Issue-191: Assessment of Debris Accumulation on PWR Sump Performance

Joint Meeting of the ACRS Subcommittees on Thermal-Hydraulics Phenomena and Reliability and PRA

September 3, 2014

Introductions and Agenda

- Introductions, Speakers
  - Mike Murray, Manager Regulatory Affairs, STPNOC
  - Ernie Kee, Risk-Informed GSI-191 Technical Team Lead, STPNOC
  - Kerry Howe, Chemical Effects, Ph.D., University of New Mexico
  - David Johnson, Sc.D., ABS Consulting
  - Janet Leavitt, Ph.D., Alion Science & Technology
  - Bruce Letellier, Ph.D., Alion Science & Technology
  - David Morton, Ph.D., University of Texas, Austin
  - Rodolfo Vaghetto, Ph.D., Texas A & M University

Introductions and Agenda

- Additional STPNOC Attendees
  - David Rencurrel, Vice President, INPO Consultant, STPNOC
  - Rob Engen, Engineering Projects Manager, STPNOC
  - Steve Blossom, Risk-Informed GSI-191 Project Manager, STPNOC
  - Wayne Harrison, Licensing Lead, STPNOC
  - Drew Richards, Licensing, STPNOC
  - Yassin Hassan, Ph.D., Texas A&M University
  - Zahra Mohaghegh, Ph.D., University of Illinois, Urbana/Champaign
  - Seyed Reihani, Ph.D., University of Illinois, Urbana/Champaign
  - Edward D. Blandford, Ph.D., University of New Mexico
  - David Morton, Ph.D., University of Texas, Austin
  - John Hasenbein, Ph.D., University of Texas, Austin
  - Dominic Munoz, Alion Science & Technology
  - Steven Unikewicz, Alion Science & Technology

Meeting Purpose

- Review progress and changes since the last ACRS Subcommittee meeting (May 2012)
- Describe the risk-informed treatment of debris
- Provide specific examples of how results are produced

Agenda

- Introduction – Mike Murray
- Progress since last ACRS – Ernie Kee
- General Overview of PRA Process Flow – Ernie Kee
- CASA Grande interface with the PRA – David Johnson
- Thermal Hydraulic Analyses – Rodolfo Vaghetto
- In-vessel effects – Ernie Kee/Bruce Letellier
- LOCA Size/Frequency and Break Selection – David Morton/Bruce Letellier
- Treatment of Chemical Effects, including relevant testing – Kerry Howe
- Head loss, including relevant testing – Bruce Letellier
- Specific Examples (including debris generation and transport and coatings) – Bruce Letellier/Dominic Munoz

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Progress since May 2012 ACRS

- Regulatory interface
  - License Amendment Request (LAR) submitted 2013
  - Set #1 Requests for Additional Information (RAIs) – 249 RAIs responded to in 3 packages
- Additional insights and review support
  - Quantifications: 12/2011, 05/2013, 11/2013, all show "very small" risk
  - Sensitivity studies completed
  - Additional confirmatory chemical effects tests completed that support and enhance previous chemical effects observations (ICET, T1, T2, bench top tests)
    - T3 and T4 "overloaded" tests
    - T5 repeat of T2 (LLOCA) with "blender beds".
  - Expanded thermal-hydraulics capabilities and analyses
    - Containment response study using coupled RELAP5-3D and MELCOR
    - Core blockage scenarios simulations using RELAP5-3D
    - Flow visualization and 3D animations
- New engineering analyses developed to quantify safety margin in head loss (including chemical effects) that incorporate more experimental data
- ECCS strainer bypass testing and data fit

Principal Findings and Assumptions

- Thermal hydraulic calculations show successful cooling with 100% core and core bypass blockage following sump switchover for all hot leg breaks and small cold leg breaks
- Testing of STP post-LOCA sump fluids shows no evidence of significant precipitation
- Sensitivity studies show that F/A fiber load (7.5g/FA) is the risk-dominant threshold
- Strainer testing performed to quantify filtration efficiency and shedding rate
  - Effectively controls core failure potential

Agenda

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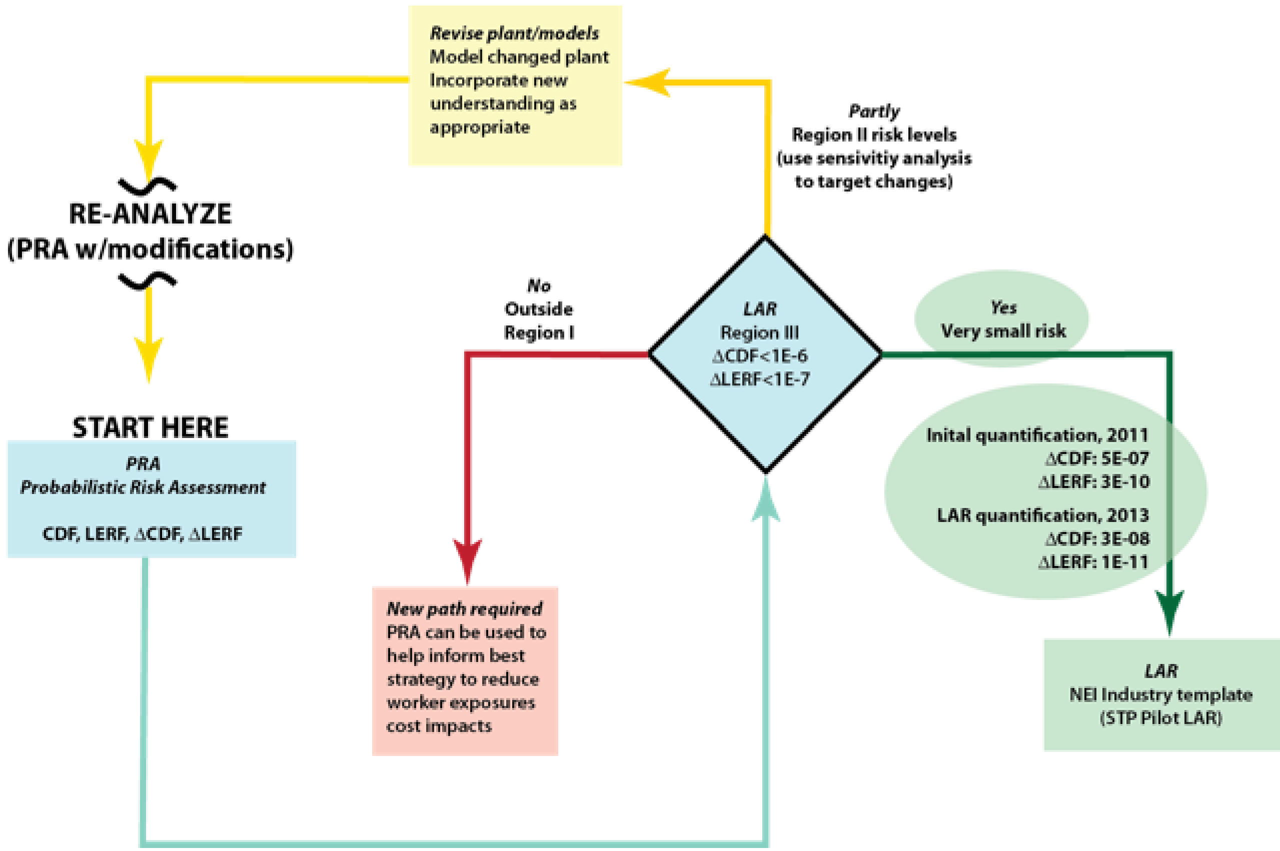
General Overview of Process Flow

Expectations for improved performance: Strainer modifications, targeted insulation removal, and operational methods, and procedure changes (design and maintenance).

Quantitative assessment: Quantify measures of risk to assess qualitative expectations for safe operation derived from the changes put in place

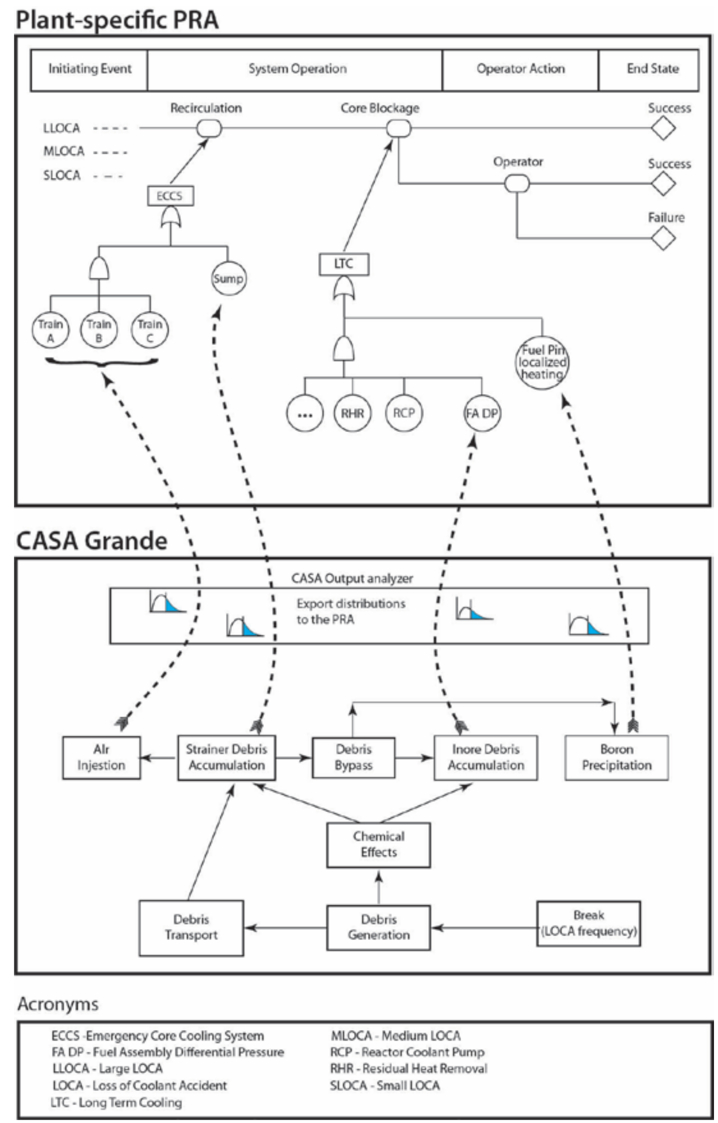


PRA Support Required for Realistic Quantification of the Concerns Raised in GSI-191

- The existing recirculation failure probability required additional rigor and analysis
  - Conditional failure likelihoods required support derived from prudent, peer-reviewed, data and engineering analyses
  - An additional top event for in-vessel failures was required (current plant risk assessments and)
  - Previously developed and accepted engineering models were adopted where possible to reduce development and regulatory review burden
- Use of existing plant procedures, processes, and programs for PRA of plant risk applications such as Maintenance Rule, risk-managed technical specifications, risk categorization, significance determination process
- Use existing industry and regulatory standards for PRA quality

High Level Representation of Integrated Model

- In the integrated model, developed in this project, plant-specific PRA is located at the top level of system analysis
- CASA Grande provides likelihood estimates for a few basic events for the plant-specific PRA by modeling their underlying physical phenomena and, by adding uncertainty analysis to the physical models



Calculating ΔCDF, CDF, ΔLERF, LERF - PRA

- CASA Grande develops and passes to the PRA discrete distributions of conditional failure probabilities:
  - Conditioned on LOCA initiating event frequency
  - Conditioned on plant state (pump combination)
  - For top events:
    - Sump failure due to NPSH margin
    - Sump voiding
    - Sump mechanical collapse
    - Core cooling fiber loading
    - Core boron precipitation fiber loading
- Initiating event distributions (consistent with the mean of NUREG 1829) are supplied to the PRA for small, medium and large LOCA

CASA Grande Calculation Process Steps

1. Set plant failure state (number of trains, and specific pumps available). Failure state determines available flow rates through each train and guides operator action via EOPs.
2. Randomly select a weld type/case based on relative frequency of break occurrence. Relative frequencies reflect susceptibility to degradation (failure).
3. Randomly select a specific weld from this type/case (equal probability among all welds of same type/case). Weld location defines $P(x, y, z)$, and Hot Leg or Cold Leg break condition. Each weld location has a pre-calculated list of insulation targets that can be "seen" in every direction. Concrete walls are the only feature that can shield insulation from potential damage. We assume pipes and large equipment to have no effect on a ZOI.

Calculation Process Steps

4. Conditional upon having a break for this specific weld type/case, sample a break diameter that is consistent with NUREG-1829:

   $$D_{break} \sim F_{D_{break} | \, weld\ case}.$$

   Record break contribution to SLOCA, MLOCA, or LLOCA category. The designation of SLOCA, MLOCA, or LLOCA becomes an explicit correlation for many following physical variables, both user-specified input (like typical times for operator action, chemical head-loss increase, containment pool volume, etc.) and externally computed trends (like temperature histories).

5. Select a complete temperature history $T(t)$ from appropriate correlations of thermal-hydraulic trends for SLOCA, MLOCA, or LLOCA events. The temperature history drives water properties, assumed arrival of chemical products, and $NPSH_{margin}$.

Calculation Process Steps

6. Calculate radii $R_{i,j,k}$ of the three damage zones indexed by $i = 1, 2, 3$, debris sizes (fines, small pieces, large pieces, or intact blankets) indexed by $j = 1, 2, 3, 4$, and target type indexed k, where $k \in \mathcal{K}$ indexes insulation products in containment. We distinguish three sets indexed by k: $\mathcal{K}$ denotes insulation products, $\mathcal{F}$ denotes fiber-based insulation, and $\mathcal{L}$ denotes all types of debris, including insulation and other debris such as unqualified coatings and crud particulate; so, $\mathcal{F} \subset \mathcal{K} \subset \mathcal{L}$. The $R_{i,j,k}$ damage zones for Nukon are scaled to the maximum damage radius for insulation k. The figure is an illustration that shows the nomenclature of damage for a hypothetical break that has its damage radii truncated by a wall.

Calculation Process Steps

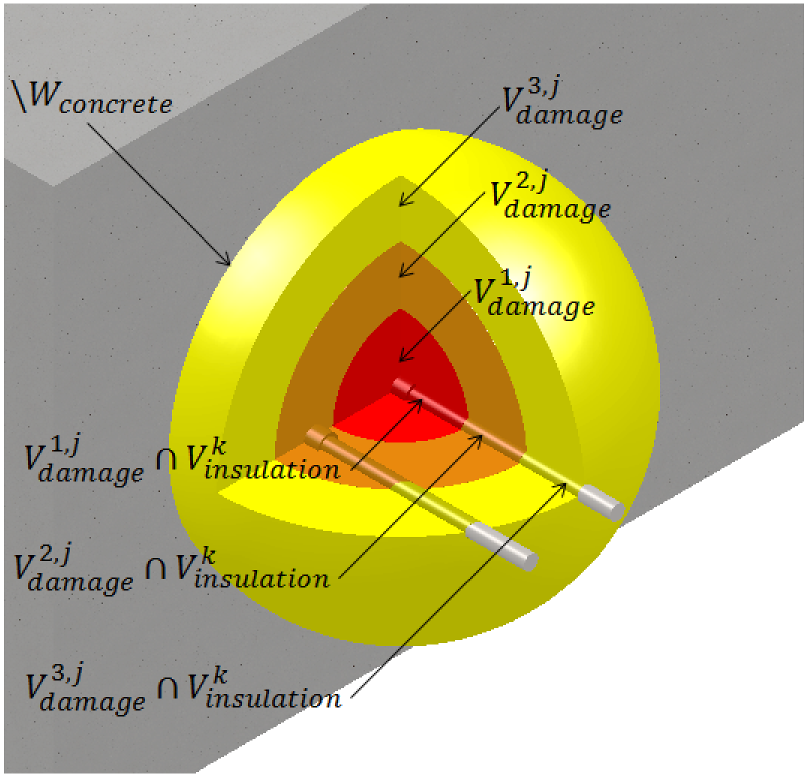


Figure 1: Illustration of a hypothetical spherical break (double-ended guillotine) damage zone truncated by a wall with the nomenclature of the damage characteristics

Calculation Process Steps

7. If $D_{break} < D_{pipe}$ then choose random direction perpendicular to pipe according to $\phi \sim U(0, 2\pi)$. Else, ϕ is assigned a flag that indicates a spherical ZOI.
8. Calculate intersection of damage zones with insulation targets and clip by concrete walls to obtain amount of debris in each damage radius and debris size (i, j, k), and convert volume to mass:

$$M_{i,j,k} = \rho_k \left| \left(V^{i,j}_{damage}(\phi) \cap V^{k}_{insulation} \right) \setminus W_{concrete} \right| . \tag{1}$$

Here, the "$\setminus W_{concrete}$" designates exclusion of those insulation targets not damaged due to structural concrete blocking the break blast.

Calculation Process Steps

9. Apply transport logic diagram to obtain all ZOI-generated debris mass arriving at the containment sump pool. Complex transport logic is represented here via the operator $F_{transport}$:

$$m^P(0) = F_{transport} \otimes M. \tag{2}$$

   The transport logic captures, e.g., erosion of fibers from large pieces to fines, in transforming the vector M of $M_{i,j,k}$ to the vector $m^P(t)$ of $m^P_{i,j,k}(t)$ $t = 0$.

10. Introduce fixed quantities of non-ZOI debris types (those in $\mathcal{L}$ but not $\mathcal{K}$ and not addressed above) like crud particulate, latent debris, and unqualified coatings debris.

Calculation Process Steps

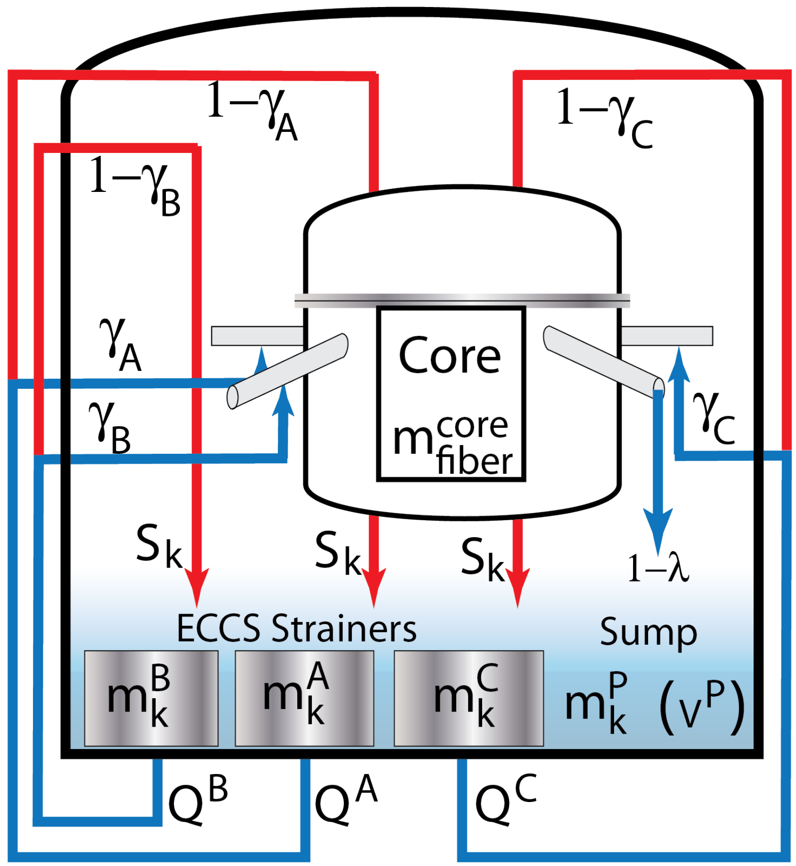
11. Apply fill up transport fraction, F^{ℓ}_{fill}, to train ℓ's strainer sump cavity. This mass of debris is initially resident on each strainer, in addition to all other debris constituents that arrive over time:

$$m^{\ell}_{i,j,k}(0) = F^{\ell}_{fill}\, m^{P}_{i,j,k}(0). \tag{3}$$

12. At each time t, assume homogeneous mixing in the pool:

$$C^{P}_{i,j,k}(t) = m^{P}_{i,j,k}(t)/V^{P}(t). \tag{4}$$

Calculation Process Steps



Cold leg break geometry

S_k - k^{th} insulation type in the containment spray flow

λ - Fraction of total ECCS strainer flow going to the vessel

$\gamma_{A,B,C}$ - Fraction of total ECCS strainer flow going to the vessel

$m_k^{A,B,C}$ - Mass of k^{th} insulation on the (A,B,C) ECCS strainer, and (P) in the sump pool

v^P - Volume of water in sump pool

$Q^{A,B,C}$ - Total (A,B,C) strainer flow

m_{fiber}^{core} - Mass of fiber in core (only fiber is rtransported to the core)

Figure 2: Illustration of the processes local to the ECCS screen that contribute to direct pressure drop on the screen that lead to decreased *NPSHA* and downstream effects such as fiber penetration contributing to m_{fiber}^{core} and bubble formation during the recirculation phase.

Calculation Process Steps

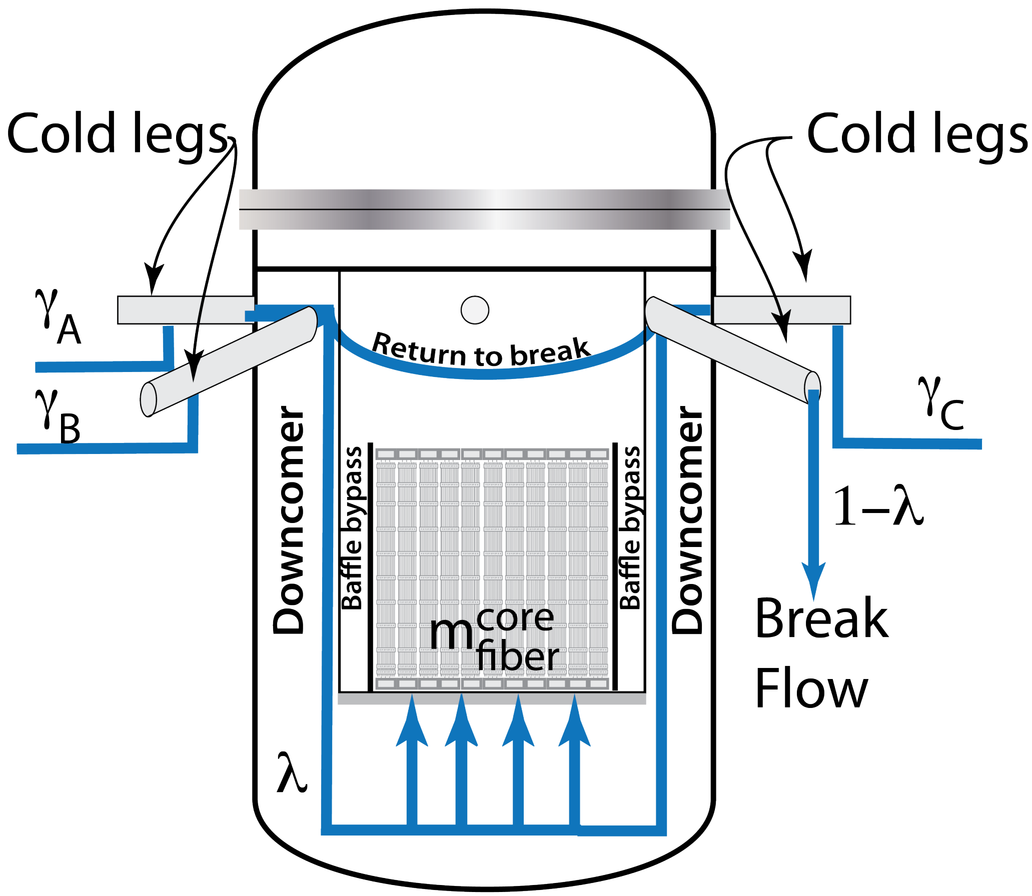


Figure 3: Illustration of the flow paths in the reactor vessel used to establish m_{fiber}^{core} accumulation and fiber bypass during the recirculation phase of ECCS operation in a medium or large cold leg break scenario.

Calculation Process Steps

13. Solve coupled differential equations for mass in the containment sump pool, mass on strainer and mass on core per the nomenclature shown on the figures on prior slides:

$$\frac{d}{dt}m_k^P(t) = S_k(t) - \sum_{\ell=A,B,C} \frac{d}{dt}m_k^{\ell}(t) - \left.\frac{d}{dt}m_k^{core}(t)\right|_{k\in\mathcal{F}}, \ \forall k \in \mathcal{L} \tag{5a}$$

$$\frac{d}{dt}m_k^{\ell}(t) = f\left(\sum_{k\in\mathcal{L}} m_k^{\ell}(t)\right)(Q^{\ell}(t)/V^P(t))m_k^P(t) - \eta\nu\, m_k^{\ell}(t), \ \forall k \in \mathcal{L}, \forall \ell \tag{5b}$$

$$\begin{aligned}\frac{d}{dt}m_k^{core}(t) = {} & \lambda \sum_{\ell=A,B,C} \gamma_{\ell}\left[1 - f\left(\sum_{k\in\mathcal{L}} m_k^{\ell}(t)\right)\right](Q^{\ell}(t)/V^P(t))m_k^P(t) \\ & + \lambda\eta \sum_{\ell=A,B,C} \gamma_{\ell}\nu m_k^{\ell}(t), \ \forall k \in \mathcal{F},\end{aligned} \tag{5c}$$

Calculation Process Steps

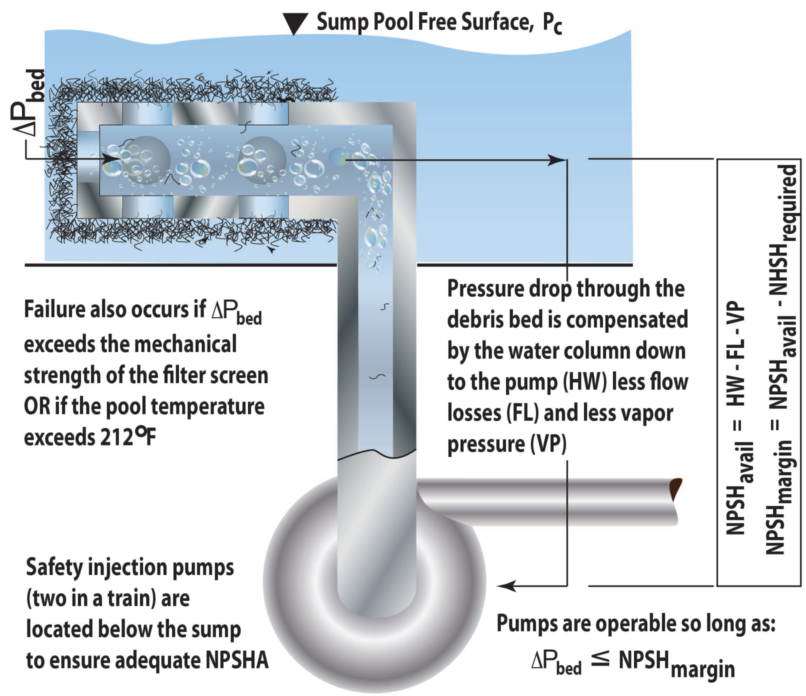


Figure 4: Illustration of the sump pool, screen, and pump annotated with the head losses to the SI pump suction. Also shown is the failure criteria associated with the pressure losses to the pump.

Calculation Process Steps

14. Given histories of fiber and particulate debris thickness, $\delta(t)$, on the strainer, compute time-dependent head loss across each strainer according to:

$$\Delta P^{\ell}(t) = H(m^{\ell}(t), Q^{\ell}(t)) N(5,1) \Phi_{ch}(t) \tag{6}$$

where, the function H is head loss due to strainer loadings,$m^{\ell}(t)$ of $m_k^{\ell}(t)$ for all $k \in \mathcal{L}$, and velocity via the flow rate $Q^{\ell}(t)$, and where $N(5,1)$ is a truncated normal random variable with a mean of 5 and unit variance, and where

$$\Phi_{ch}(t) = \begin{cases} 1, \ \delta(t) < \frac{1}{16}'' \text{ or } T(t) > N(140,5) \\ \mathcal{E}, \text{ otherwise.} \end{cases}$$

Here, Φ_{ch} takes value 1 if the thickness is below 1/16-th of an inch or the temperature exceeds the specified normal random variable, centered on 140^{o}F. Otherwise, Φ_{ch} takes the value of a shifted, and truncated, exponential random variable, which we denote by $\mathcal{E}$.

Calculation Process Steps

15. Compare time-dependent head loss to time-dependent NPSH and record the scenario as a failure if:

$$\max_{t,\ell}\left[\Delta P^{\ell}(t) - NPSH_{margin}(t)\right] > 0, \tag{7}$$

i.e., we record a failure for this scenario if the head loss exceeds the NPSH margin for any strainer $\ell = A, B, C$.

16. Compare time-dependent head loss to fixed mechanical collapse criterion and record the scenario as a failure if:

$$\max_{t,\ell} \Delta P^{\ell}(t) > \Delta P_{mech}, \tag{8}$$

where ΔP_{mech} is the design strainer mechanical strength inferred by the pressure drop across the strainer.

Calculation Process Steps

17. Given time-dependent head loss, calculate time-dependent gas evolution and record the scenario as a failure if:

$$\max_{t,\ell} F_{void}(\Delta P^{\ell}(t)) > 2\% \tag{9}$$

18. For cold leg break, compare the time-dependent fiber accumulation on the core against the assumed $7.5gm/FA$ threshold. Record a scenario failure if $\max_t m^{core}(t) > 7.5gm/FA$.
19. Given time-dependent fiber on the core, record scenario success for all hot leg breaks.
20. If any performance threshold (for any scenario) is exceeded then record a failure.

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Adapting the STP PRA

- Role of PRA in the STP Risk-informed investigation of GSI-191
- Modifications made to Model of Record
- Meeting Requirements of Revision 2 of Regulatory Guide 1.200
- Results
- Observations

Role of PRA

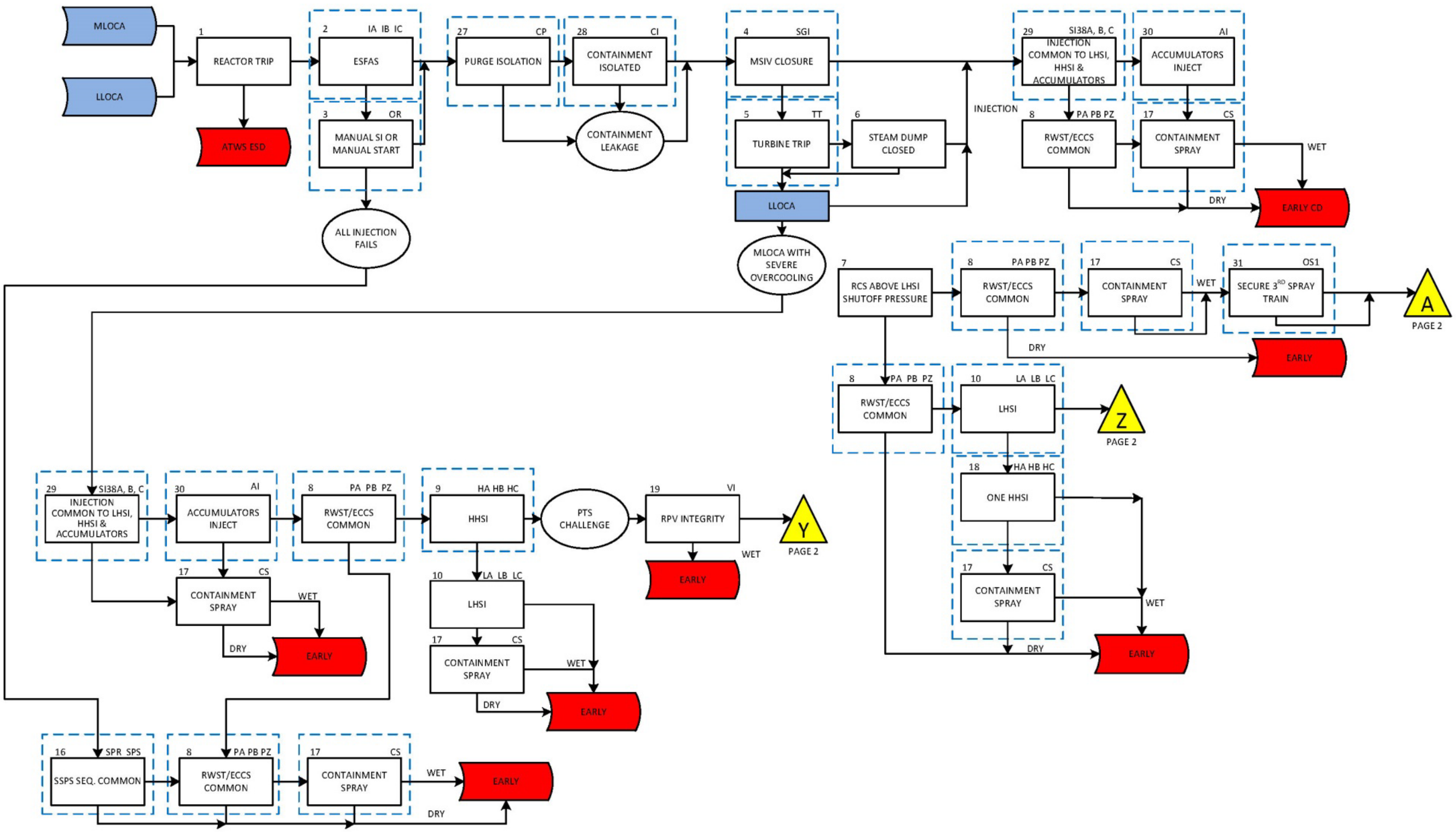
- Goal:
  - integrate results provided by CASA Grande and Initiating Event model to quantify CDF, LERF, ΔCDF and ΔLERF
  - determine characteristics of uncertainty in metrics

- For purposes of addressing RG 1.174 requirements, comparison is made to hypothetical plant with no GSI-191 impacts

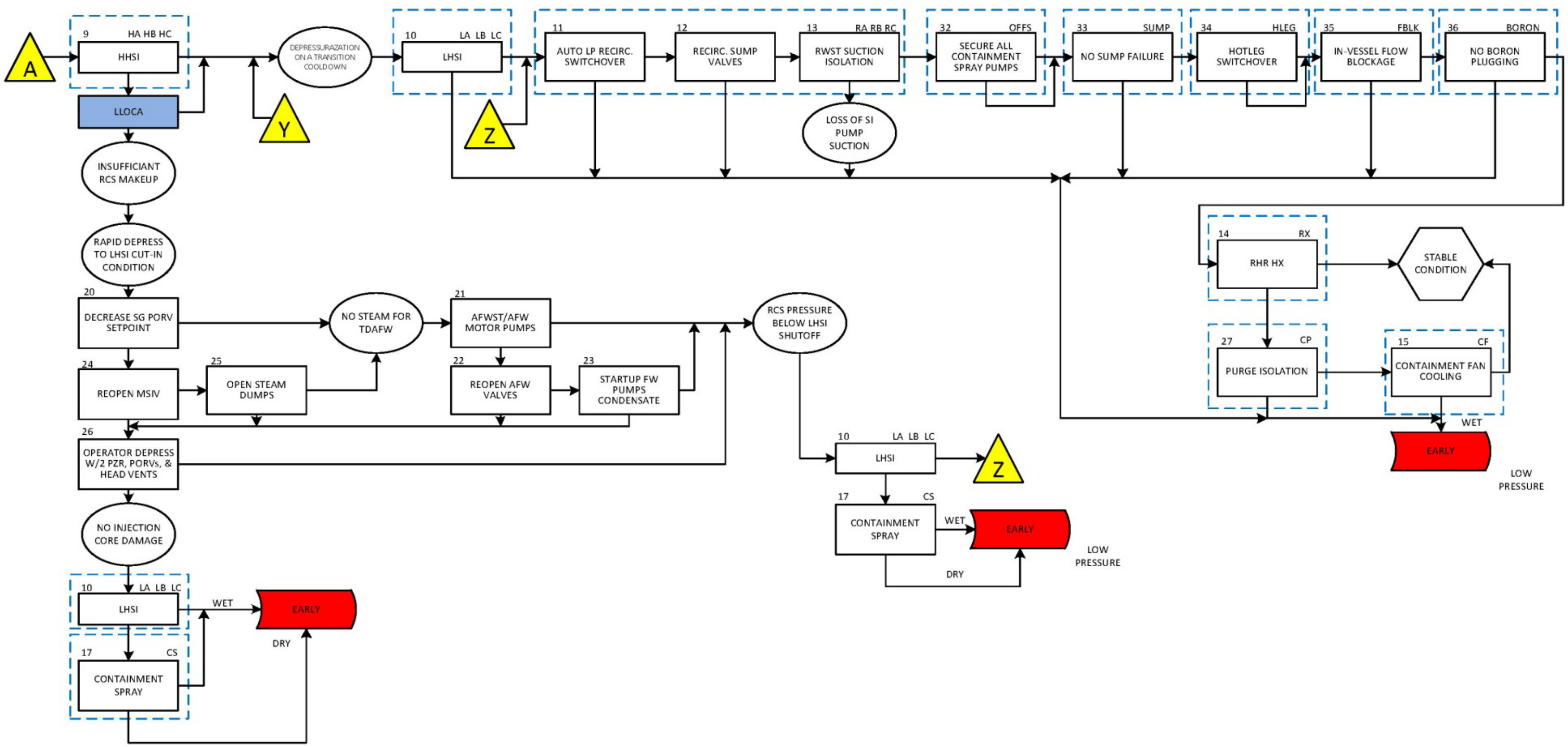
Modifications made to Model of Record (MOR)

- Differences in success criteria
  - Status of all pumps taking suction from sump is of interest
- Different LOCA frequency model
- New scenarios added
- MOR uses ‘generic’ sump blockage likelihood; GSI-191 License Amendment Request model uses detailed plant-specific evaluations
- Failures after 24 hours addressed
- The effect may be small necessitating lower quantification truncation limit

Single Medium/Large LOCA Logic Model

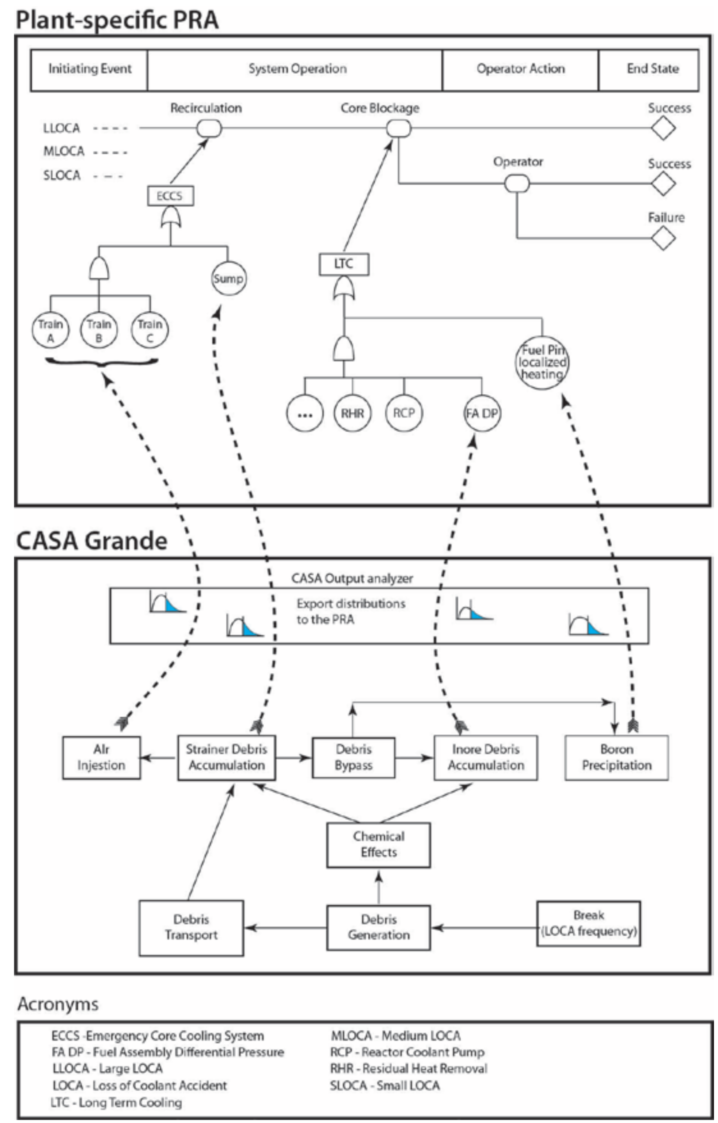


Single Medium/Large LOCA Logic Model, continued



Relationship between CASA Grande and PRA

- In the integrated model, developed in this project, plant-specific PRA is located at the top level of system analysis
- CASA Grande provides likelihood estimates for a few basic events for the plant-specific PRA by modeling their underlying physical phenomena and, by adding uncertainty analysis to the physical models



Interface with CASA Grande

- CASA Grande analyzes pump configuration and returns conditional failure probability representing core cooling failure due to phenomena considered
- Based on flow from pumps actively taking suction from sump
  - Containment spray, low head and high head pumps
- Basic events representing phenomena of interest added to PRA model

Analysis Duration

- New basic events include representation of plant response for new phenomena beyond 24 hours
- Mission time for ‘base case’ remains 24 hours
  - 24 hour mission time is a convention. The basis is an assumption that this mission time provides a reasonable representation of long term actions, recovery, etc., without specific detailed modeling.
  - ‘new’ phenomena being added to PRA represent ‘new’ failure sequences branching from sequences that otherwise would be counted as ‘success’
  - Since primary interest is in estimating delta CDF and LERF relative to a base case, an ‘underestimate’ of the base case would increase calculated delta CDF and LERF attributed to new phenomena
  - Omission of equipment failures after 24 hours not related to GSI 191 phenomena maximizes impact of new phenomena
  - Equipment failures after 24 hours not related to GSI 191 would be the same for the ‘as is’ case and RMI case – no contribution to delta CDF or delta LERF

Meeting Requirements of RG 1.200

- Determine status of compliance of the plant-specific MOR
- Identify PRA elements relevant to GSI-191
  - Credit taken for sump recirculation
  - Scenario has potential to liberate insulation
  - Scenario includes transport mechanism
- Identify relevant supporting requirements from RG 1.200 and compare to relevant PRA elements

Summary of Results I

Table 4-1 Comparison of Small, Medium and Large LOCA Initiating Event Frequencies (mean values, $year^{-1}$)		
	STP PRA Revision 7.1	GSI-191 PRA
Small LOCA	3.45×10^{-4}	1.59×10^{-3}
Medium LOCA	4.95×10^{-4}	3.05×10^{-4}
Large LOCA	1.37×10^{-6}	5.20×10^{-6}

Table 4-2 Comparison of Core Damage Frequency and Large Early Release Frequency (mean values, $year^{-1}$)			
	STP PRA Revision 7.1	GSI-191 PRA – Base Case (without GSI-191 Phenomena)	GSI-191 PRA –(with GSI-191 Phenomena)
Core Damage Frequency	7.80×10^{-6}	9.20×10^{-6}	9.23×10^{-6}
Large Early Release Frequency	5.73×10^{-7}	5.78×10^{-7}	5.78×10^{-7}

Summary of Results II

- ΔCDF is very small 2.88×10^{-8} per year.
- ΔLERF is very small (calculated to be 1.40×10^{-11} per year)
- 95th confidence bound on ΔCDF is 1.3×10^{-7} per year

- Notes:
  - sequence frequency truncation limit 1×10^{-14} (MOR used 1×10^{-12})
  - Bounding model used to represent pump states not analyzed in CASA Grande contributed approximately 25% of ΔCDF

RG 1.174 Considerations

- Comparison of difference between risk from debris effects on “as-is” plant and risk with no debris effects
  – Can bound ΔCDF and ΔLERF for STP by considering new phenomena in all sump recirculation success sequences
  – No debris effects evaluation
    - Assumes GSI 191 issues have no impact
- Quantification, at-power conditions only, in Region III (‘very small change’)
  – Uncertainty analysis suggests high confidence change in Region III

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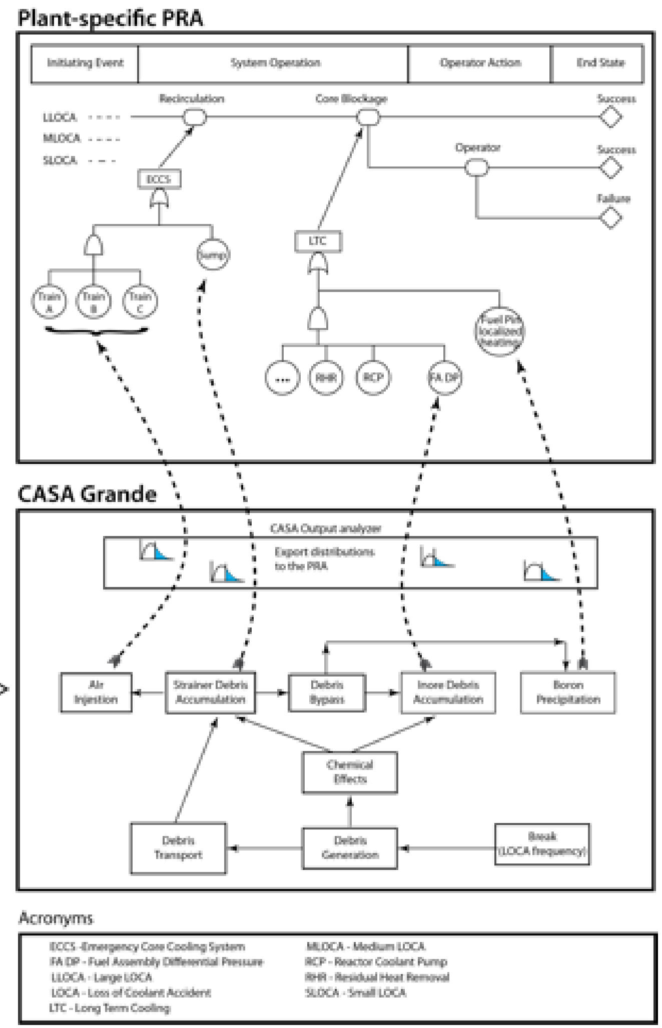
Thermal-Hydraulics

High Level Input Module

1. Containment CAD Model
2. ~~LOCA Frequency Data~~
3. Thermohydraulic Data
4. ~~Debris Generation Data~~
5. Chemical Effects Data
6. Debris Transport Data
7. Strainer and Core Geometry

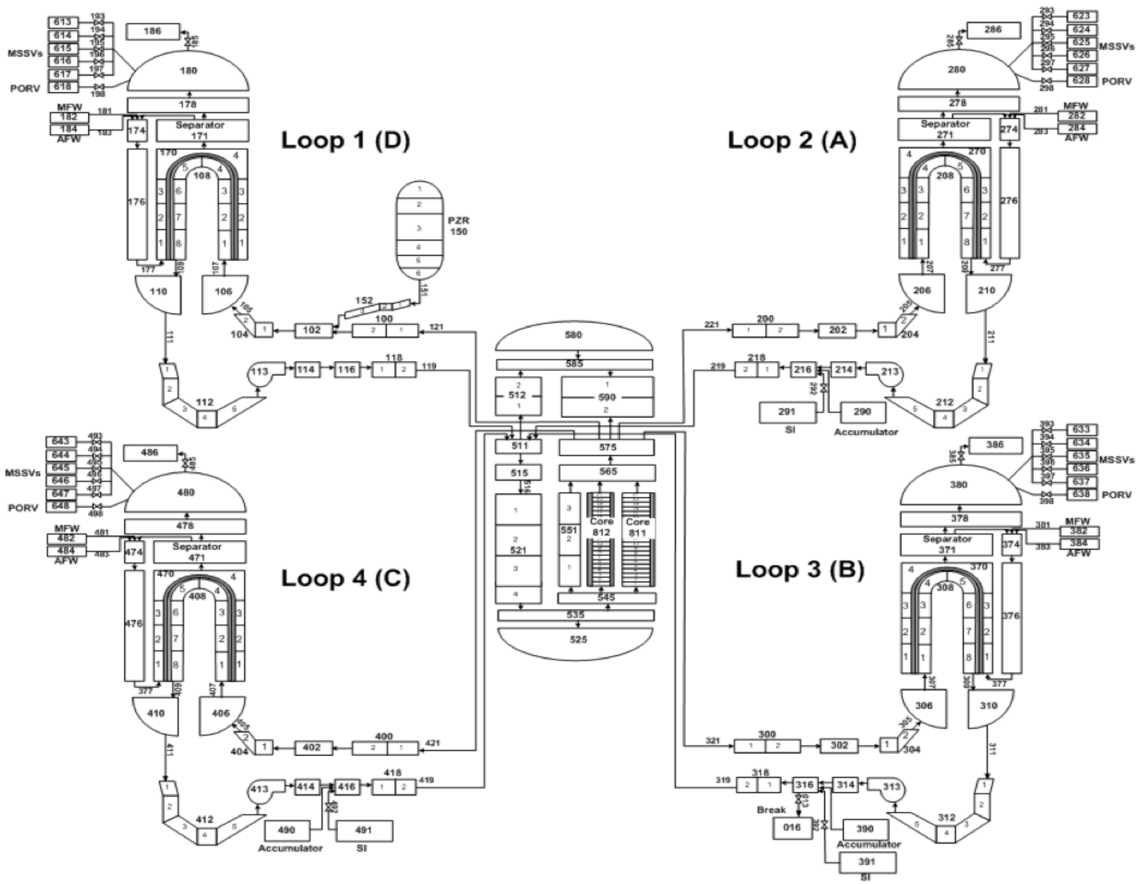


Thermal-Hydraulics

System Codes used for the analyses

- **MELCOR** is used to perform simulations of the reactor containment response
- **RELAP5-3D** is used to perform simulations of the reactor system
  - Input models developed:
    - 1D Model: to perform long-term cooling simulations
    - 3D Models: to perform simulation of hypothetical core blockage scenarios
- **MELCOR** and **RELAP5-3D** were coupled to perform analyses of the reactor system and containment during LOCA scenarios

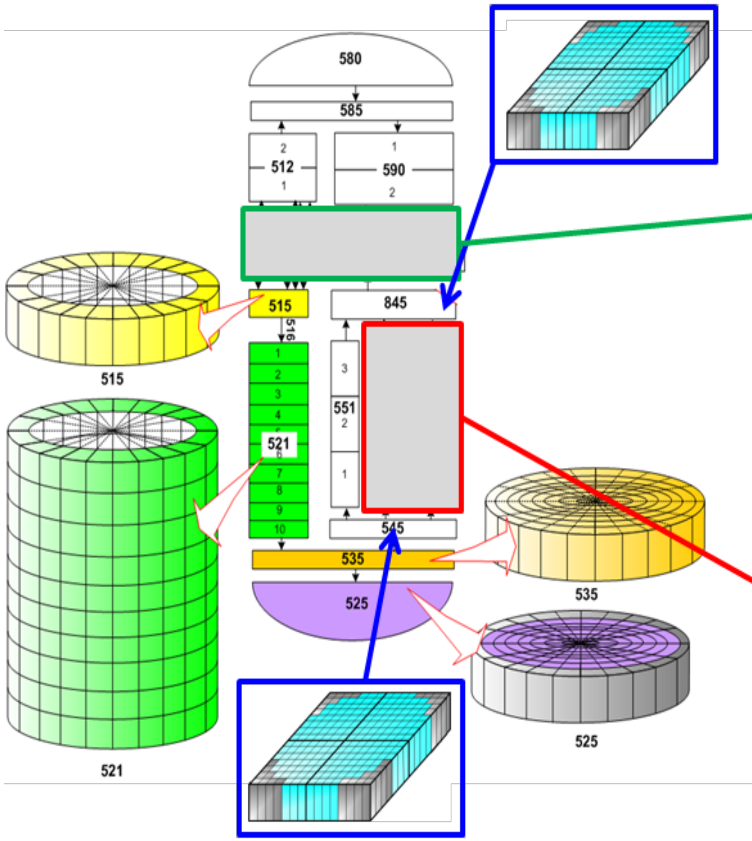
Thermal-Hydraulics, RELAP5 1D Model

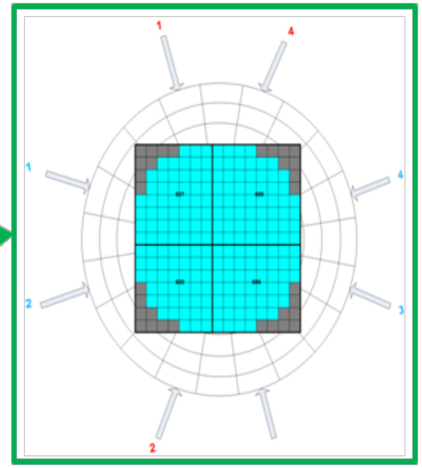


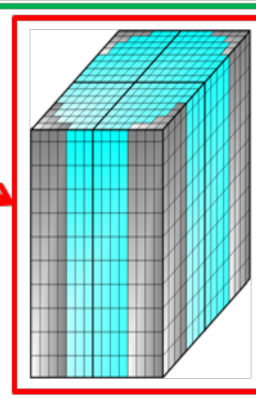
Main Features

- Typical model for a PWR 4-loop
- 4 independent loops
- 1D core (2-channel, 21 axial nodes)
- 3 Independent SI trains
  - HPSI
  - LPSI
  - Accumulator
- Long-term cooling operations included (sump switchover, hot leg switchover)
- Different break sizes
- Different break locations
- Different boundary conditions

Thermal-Hydraulics, RELAP5 3D Model

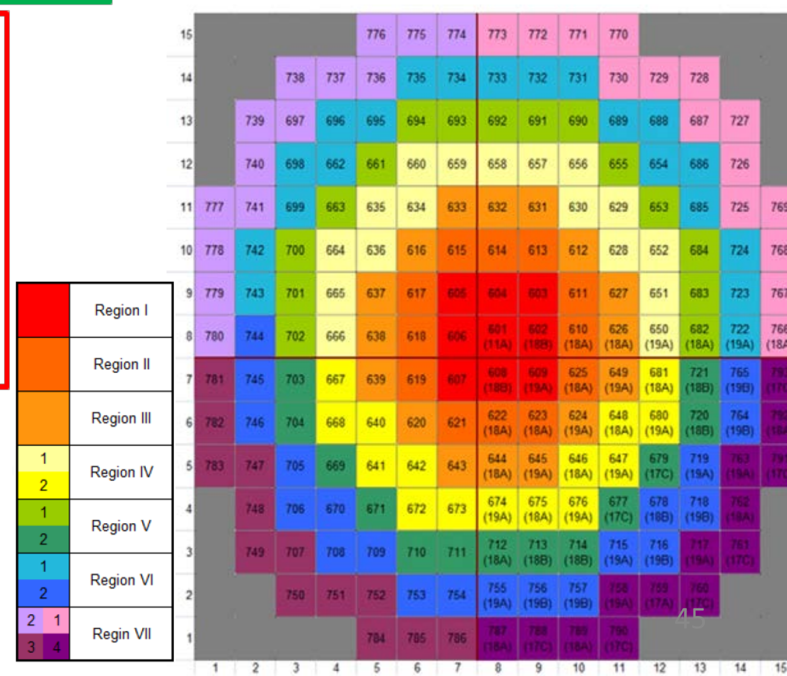




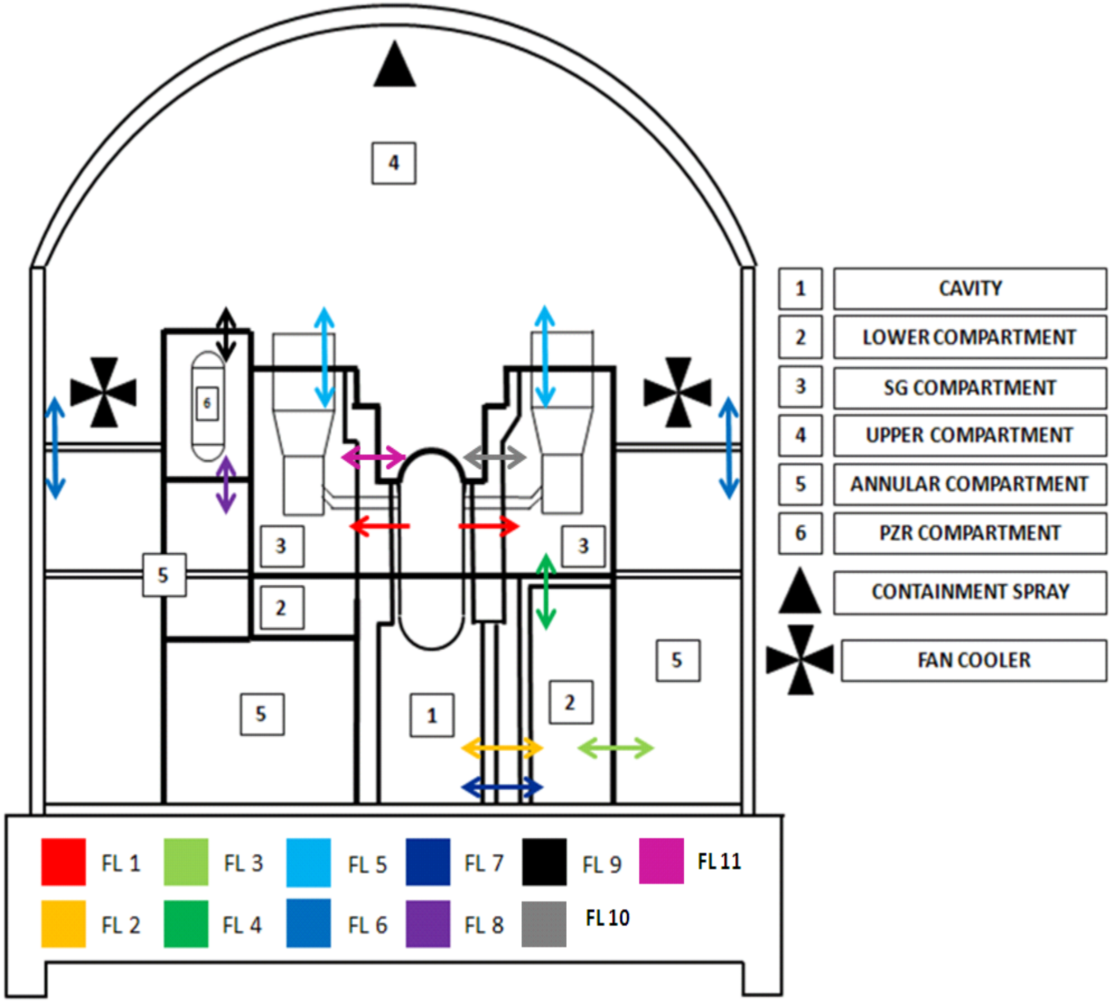


Main Features

- All 1D-model features included
- 193 fuel channels simulated
- STP core fuel arrangement
- 193 heat structures
- Realistic core axial and radial power distributions
- 2123 nodes in the core



Thermal-Hydraulics, MELCOR Model



Main Features

- 6 control volumes
- 11 flow paths
- 49 heat structures
  - Floors, ceilings, and walls
- Engineered safety features
  - Containment Sprays
  - Fan Coolers

Thermal-Hydraulics, Simulations Executed (1/6)

- **Sump Temperature Profile calculations – CHLE Tests**
  - 6”   break in cold leg (loop 3) – 30-day
  - 15” break in cold leg (loop 3) – 30-day

- **Containment Response Analysis**
  - Different break sizes: 1.5”, 2”, 4”, 6”, 8”, DEGB (27.5”)
  - Operating spray pumps: 3, 0
  - Operating fan coolers: 6, 2
  - Operating RHR heat exchangers: 3, 0
  - CCW temperature conditions: Nominal (85.84 °F), Summer (150 °F), Winter (60 °F)

Thermal-Hydraulics, Simulations Executed (2/6)

Case	Break Size (Diameter)	Working HHSI Pumps	Working LHSI Pumps	Working CS Pumps	Working Cont. Fan Coolers	Case Description
1.5" Nom.	1.5inches	3	3	3	6	Nominal CCW Temperature (85.84 F)
2" Nom.	2inches	3	3	3	6	Nominal CCW Temperature (85.84 F)
2" Min	2inches	3	3	3	6	Winter CCW Temperature (60 F)
2" Max.	2inches	3	3	0	2	Summer CCW Temperature (150 F) and no RHR HXs
2" No Heat Removal	2inches	3	3	0	0	no RHR Heat Exchangers, Low AFW Temperature
4" Nom.	4inches	3	3	3	6	Nominal CCW Temperature (85.84 F)
4" Max.	4inches	3	3	0	2	Summer CCW Temperature (150 F) and no RHR HXs
6" Nom.	6inches	3	3	3	6	Nominal CCW Temperature (85.84 F)
6" Nom.	6inches	3	3	3	6	Nominal CCW Temperature (85.84 F) - Low RWST Temperature (50 F)
6" Nom.	6inches	3	3	3	6	Nominal CCW Temperature (85.84 F) - 30-day long term cooling
6" Min	6inches	3	3	3	6	Winter CCW Temperature (60 F)
6" Max.	6inches	3	3	0	2	Summer CCW Temperature (150 F) and no RHR HXs
8" Nom.	8inches	3	3	3	6	Nominal CCW Temperature (85.84 F)
8" Max.	8inches	3	3	0	2	Summer CCW Temperature (150 F) and no RHR HXs
8"-43	8 inches	1	1	1	6	Dual Train (Loops 3 & 4) Failure
15" Nom.	15inches	3	3	3	6	Nominal CCW Temperature (85.84 F)
15" Nom.	15inches	3	3	3	6	Nominal CCW Temperature (85.84 F) - Low RWST Temperature (50 F)
15" Nom.	15inches	3	3	3	6	Nominal CCW Temperature (85.84 F) - 30-day long term cooling
15" Max.	15 inches	3	3	0	2	Summer CCW Temperature (150 F) and no RHR
15"-9	15 inches	3	1	3	6	Dual LHSI Pump (Loops 3 & 4) Failure
15"-22a	15 inches	2	2	2	6	Single Train (Loop 4) Failure
15"-22b	15 inches	2	2	2	6	Single Train (Loop 3) Failure
15"-22c	15 inches	2	2	2	4	Single Train (Loop 4) Failure (4 Cont. Fans Operating)
15"-26a	15 inches	1	2	2	6	Single Train (Loop 4) + HHSI Pump (Loop 3) Failure
15"-26b	15 inches	1	2	2	6	Single Train (Loop 3) + HHSI Pump (Loop 4) Failure
15"-43	15 inches	1	1	1	6	Dual Train (Loops 3 & 4) Failure
DEG Nom.	DEG (27.5 inches)	3	3	3	6	Nominal CCW Temperature (85.84 F)
DEG Max.	DEG (27.5 inches)	3	3	0	2	Summer CCW Temperature (150 F) and no RHR

Thermal-Hydraulics, Simulations Executed (3/6)

Containment Response Study

- Sump Switchover time as a function of the break size and plant conditions
- Total SI flow rate as a function of the break size and plant conditions
- Sump pool temperature profiles as a function of the break size and plant conditions

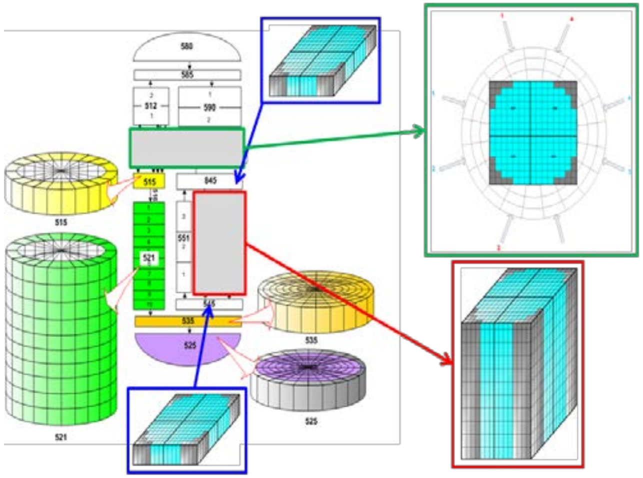
Thermal-Hydraulics, Simulations Executed (4/6)

- **Core Blockage Analysis – 1D-core model (6 simulations)**
  - Three break sizes: Small (2”), Medium (6”), Large (DEG)
  - Two break locations: cold leg, hot leg (loop 3)
  - Hypothetical instantaneous core and core bypass blockage at sump switchover

- **Core Blockage Analysis – 3D-core model (4 simulations)**
  - One break size/location: Medium (6”) / Cold leg (loop 3)
  - Different core blockage scenarios
    - Case 1: Full core/bypass blocked
    - Case 2: Core blocked free bypass
    - Case 3: Core/bypass blocked except 1 FA (center)
    - Case 4: Core/bypass blocked except 1 FA (periphery)

Thermal-Hydraulics, Simulations Executed (5/6)

Core Blockage Analysis – 3D Core
6” Cold Leg Break



Case	Description	Result
1	Full Core Blocked + Bypass Blocked	Fail
2	Full Core Blocked + Free Bypass	Pass
3	Full Core Blocked except 1 FA (Center)	Pass
4	Full Core Blocked except 1 FA (Periphery)	Pass

Thermal-Hydraulics, Simulations Executed (6/6)

Core Blockage Analysis – Summary

	Break Location	
Break Size	**Cold Leg**	**Hot Leg**
Small (2")	Pass	Pass
Medium (6")	Fail	Pass
Large (DEG)	Fail	Pass

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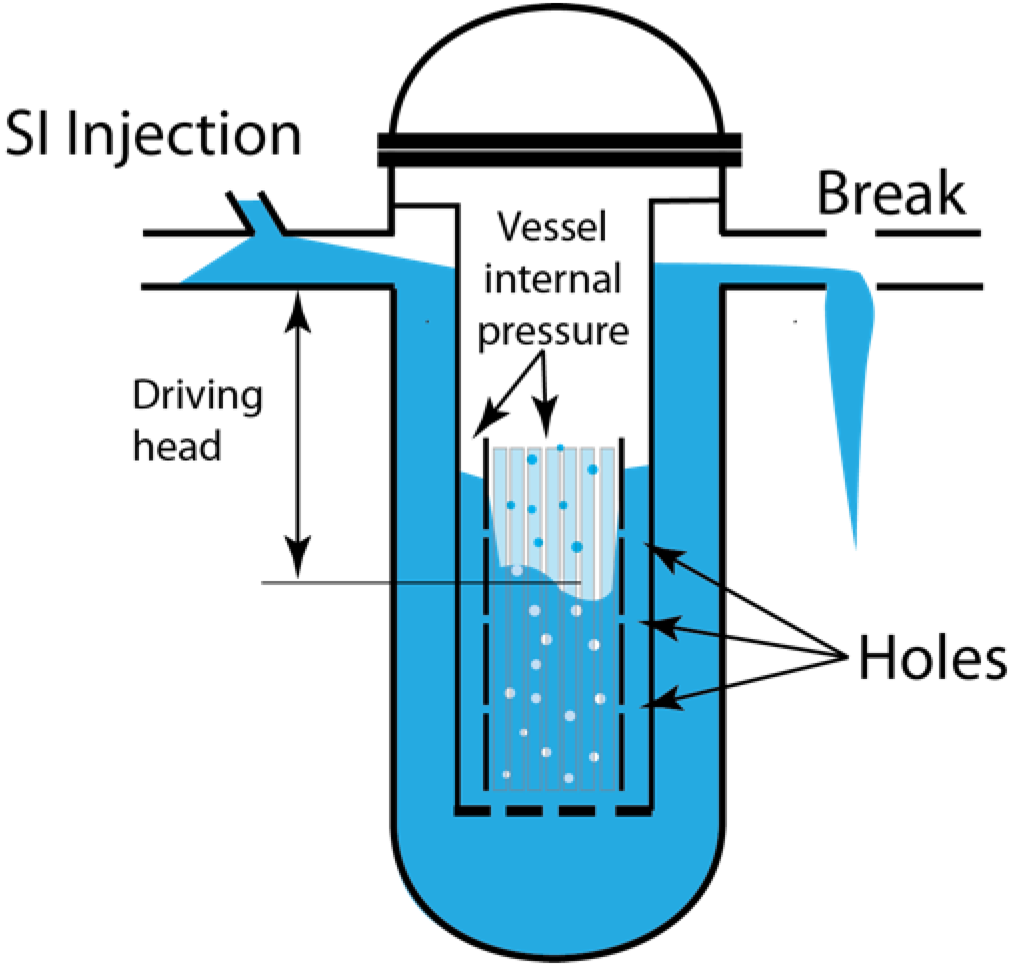
In-Vessel Effects

- Thermal-hydraulic simulations show adequate cooling for core and core bypass blockage scenarios following recirculation switchover
  - All hot leg breaks
  - Small cold leg breaks
  - One fuel assembly open for a 6 inch DEGB break
- Several rows of holes are provided in the STP core former baffle walls
  - The holes reduce the required head in cold leg breaks (SI flow doesn't have to go to the top of the core first in postulated blockage scenarios)
  - Thermal hydraulic simulations have shown the holes to be an effective cooling flow path however, the PRA success does not take credit for this flow path
- 15 gm/FA was shown (WCAP 16793) to allow sufficient cooling flow
  - A lower limit of 7.5 gm/FA is used as the success criterion
  - The lower limit provides for substantial flow in cold leg breaks so that boron precipitation is avoided
- CASA Grande samples a distribution on the time to Hot-Leg injection (defined for Small, Medium, Large by training experience)

In-Vessel Effects



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LOCA Size/Frequency

1. How should we model a continuous distribution of frequencies when NUREG-1829 elicited three discrete percentiles?
   - Use bounded Johnson distribution.
2. How should we preserve the NUREG-1829 LOCA frequencies when distributing them across different welds in the plant?
   - Use hybrid method.
3. How should we model, and sample from, a continuous distribution of break sizes when NUREG-1829 elicited percentiles at six discrete break sizes?
   - Use linear interpolation.

Hybrid Answer to Question 2 in Three Steps

Use top-down NUREG-1829 frequencies to compute:

$$P[cat_j] = \frac{Frequency[LOCA \geq cat_j] - Frequency[LOCA \geq cat_{j+1}]}{Frequency[LOCA \geq cat_1]}, \quad (1)$$

Use bottom-up frequencies to compute:

$$\Delta Freq_{bu}[LOCA \geq cat_j \text{ at } weld_i] =$$

$$Freq_{bu}[LOCA \geq cat_j \text{ at } weld_i] - Freq_{bu}[LOCA \geq cat_{j+1} \text{ at } weld_i].$$

$$w_j^i = \frac{\Delta Freq_{bu}[LOCA \geq cat_j \text{ at } weld_i]}{\sum_{i \in I_j} \Delta Freq_{bu}[LOCA \geq cat_j \text{ at } weld_i]}. \quad (2)$$

Combine:

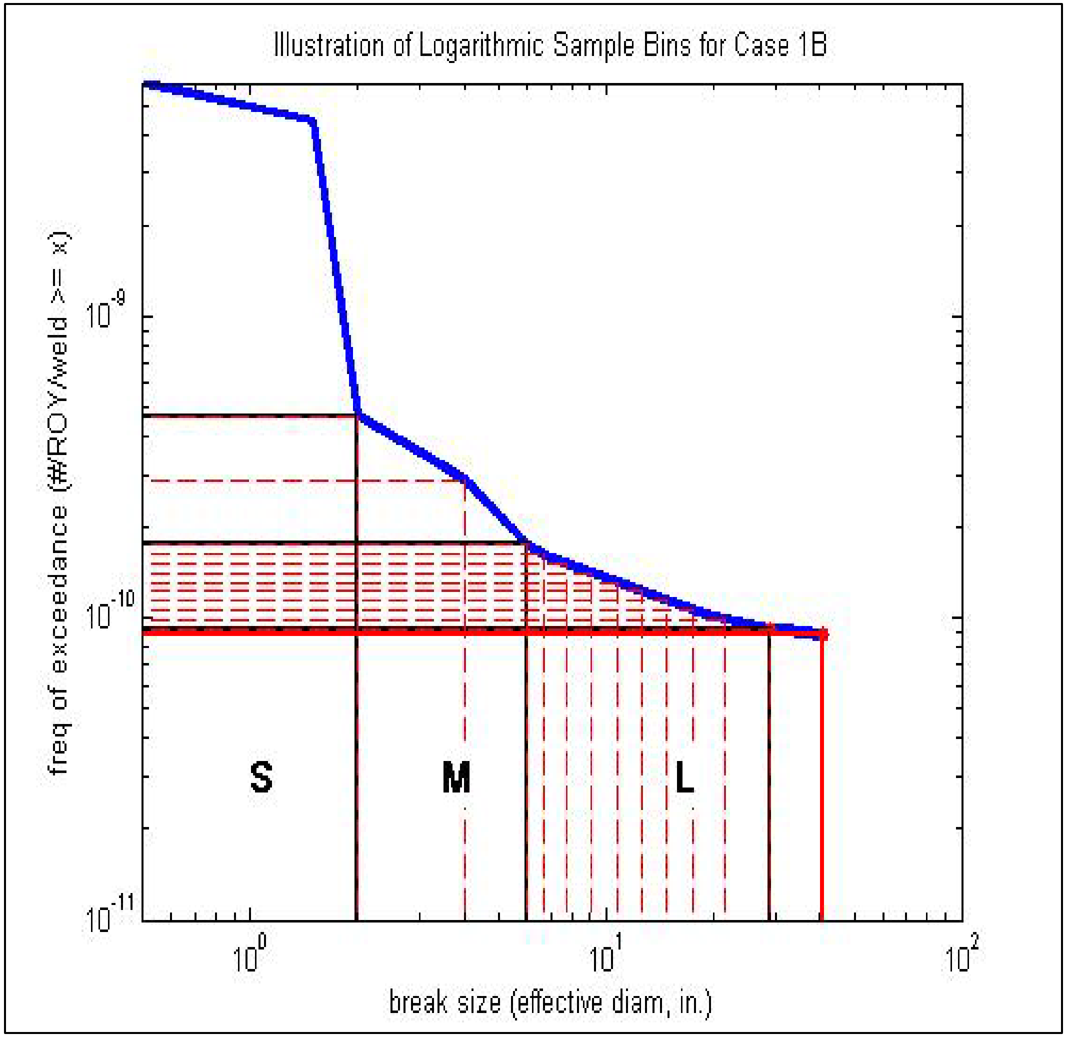
$$P[cat_j \text{ at } weld_i] = w_j^i P[cat_j]. \quad (3)$$

Break Selection

- “Hybrid” methodology for break frequency assignment:
  - Preserves total NUREG/CR-1829 frequency by size from the “top down”
  - Credits ISI, industry experience, failure modes by weld type from the “bottom up”
- Top down preserves consensus on total annual break frequency by size. Supports uncertainty propagation.
- Bottom up permits nonuniform assignment to specific locations in the plant.
- Welds chosen as higher probability locations with adequate spatial coverage of debris targets.
- Staff recommends exclusive assignment of frequency to DEGB conditions

Break Selection

- Treats break size as a continuous random variable
- Nonuniform sampling emphasizes large breaks without bias
- Breaks ≥ D_{pipe} proceed to DEGB



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Chemical Effects

- 30-day corrosion tests integrated with head loss testing.
- Three parallel head loss modules with representative debris bed for repeatability.
- Materials in corrosion tank scaled to quantities in STP containment.
- Prototypical temperature profile similar to LOCA.
- Prototypical temperature, pH, chemicals, materials, and flow rate.
- Two types of debris beds tested: NEI and blender.
- Two tests prior to LAR modeled a medium (6-inch) and large (15-inch) cold leg break.

Chemical Effects

- MBLOCA and LBLOCA test results
  - Low aqueous metal concentrations throughout tests:
    - Al < 1 mg/L
    - Reached steady state concentration in 1 to 2 days
    - Less than predicted by WCAP 16530-NP
    - Below solubility for $Al(OH)_3$ – no evidence of precipitation
  - Turbidity low and declining throughout tests indicates no precipitation formation in solution
  - No appreciable increase in head loss during MBLOCA test
  - Some scale observed on zinc surfaces in LBLOCA tests, identified as zinc phosphate
  - Presence of zinc in solution reduced the release of aluminum
  - Small increase in head loss (< .25 ft. WC) during LBLOCA test, possibly attributed to detachment of zinc scale from zinc surfaces.
- Overall outcome is that chemical effects do not significantly affect strainer head loss.

Chemical Effects

- Chemical effects included in CASA Grande to account for uncertainty
  - Head loss contribution from chemicals included as multiplier on the conventional head loss.
  - Magnitude of multiplier based on probability density functions, different for small, medium, and large LOCAs.
- Additional insights and RAI review support
  - Additional confirmatory chemical effects tests conducted to support and validate previous chemical effects observations (ICET, MBLOCA, and LBLOCA tests)
    - T3 and T4 "overloaded" tests
    - T5 repeat of T2 (LLOCA)
    - Bench tests
  - Aluminum release when TSP is present is less than predicted by WCAP 16530-NP.
  - Aluminum solubility in tank tests consistent with ANL's previous results in bench and column tests, and model predictions.
  - Confirmed aluminum release in MBLOCA and LBLOCA tests was less than the solubility limit.

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Topics for Discussion

- Chemical Head Loss (CHL)
  - STP LAR chemical inflation factor
  - Supplementary analysis of superficial loading (L*)
- Conventional Debris Head Loss
  - STP LAR modified NUREG/CR-6224
  - Available test data
  - Supplementary analysis of Re scaling (VISTA)

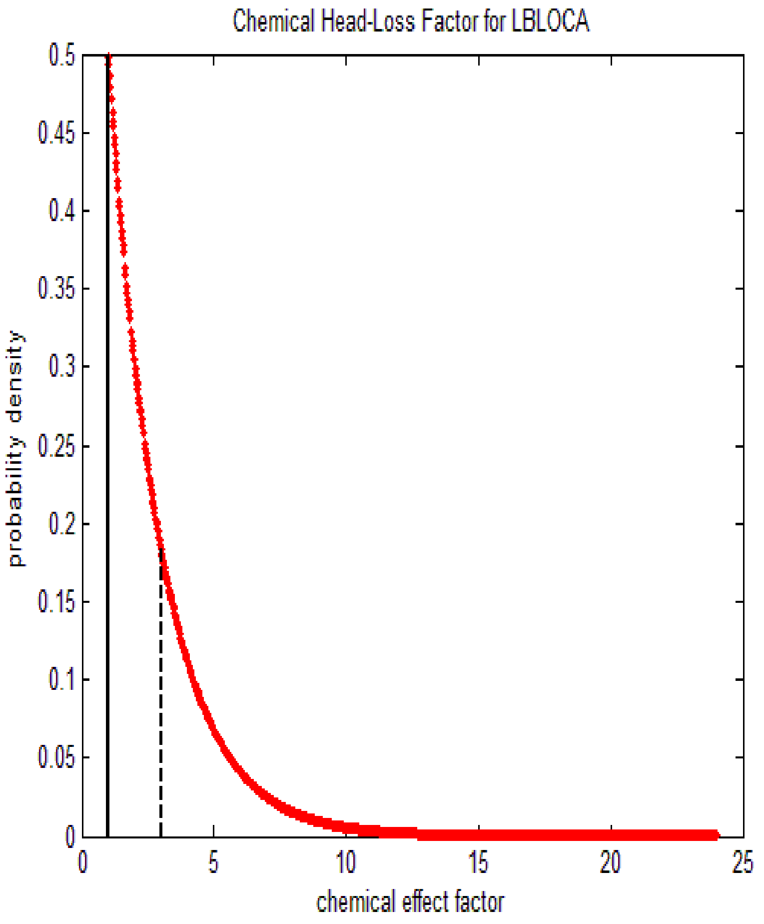
Chemical Head Loss

LAR Chemical Head-Loss Approach

- Prototypic testing of STP conditions shows no propensity for severe chemical induced HL
- Chemical Head Loss (CHL) implementation:
  - Chemical product is assumed to form when temperature falls below 140°F±N(0,5°F)
    - 5 hours for LBLOCA and 16 hours for SBLOCA and MBLOCA
  - Chemical head-loss is assumed to occur if a 1/16th-in. equivalent thickness bed is present to filter the chemicals
  - When both conditions are present, a CHL factor specific to Small, Medium, Large break is sampled and applied to the conventional debris head loss
- RAI responses examine merit of additive CHL

Exponential CHL Factors

- Shifted ≥1
- Means increase with Small, Medium, Large break (2.25, 2.5, 3.0) consistent with STP strainer testing
- Maxima selected to induce significant failures
- Stratified sampling emphasizes higher values without bias



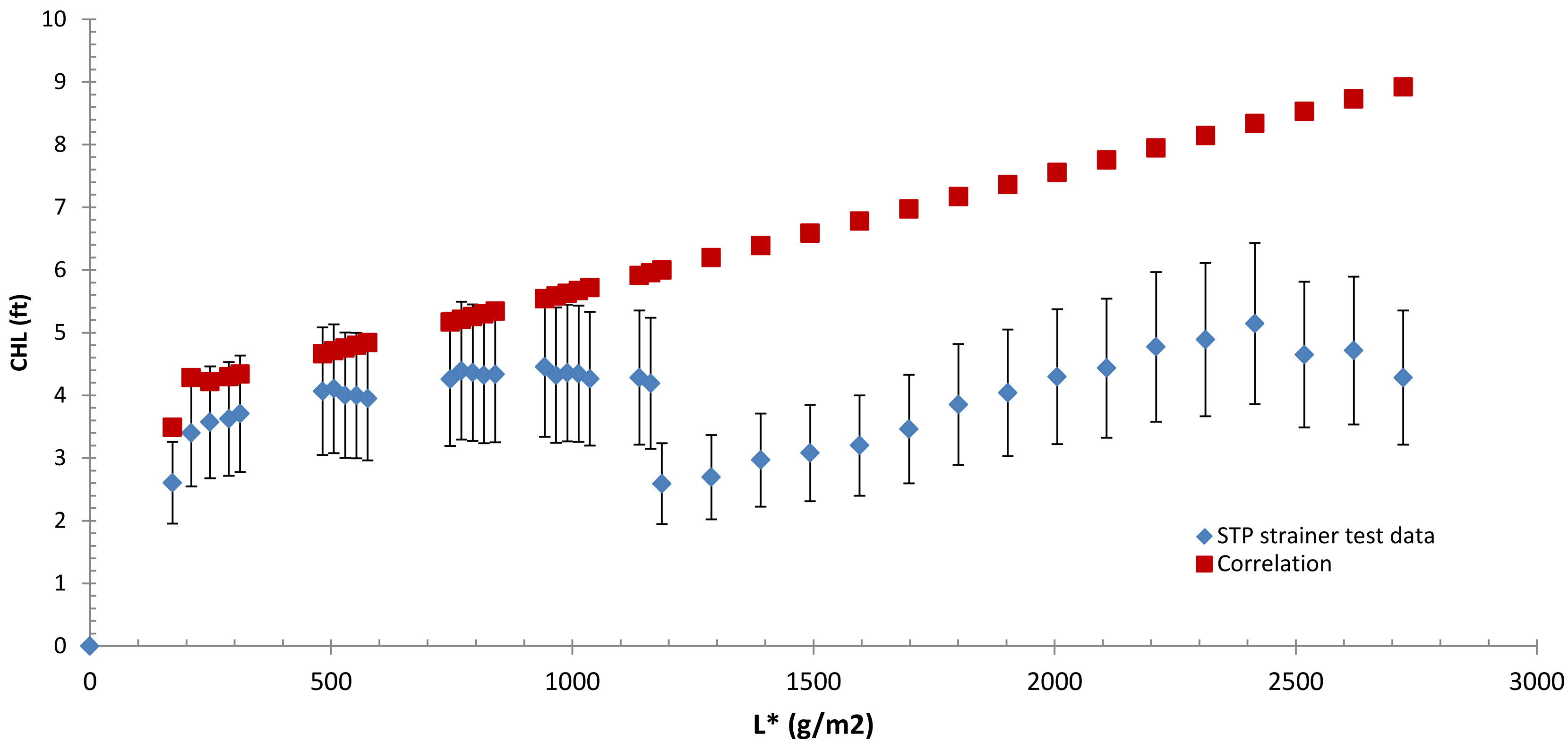
L* Approach
A Supporting CHL calculation

- Objectives
  - Address concerns that the conservatism in chemically-induced head loss (CHL) multiplicative approach is based on engineering judgment
  - Provide technical support for multiplicative approach based on best available data and accepted WCAP-16530-NP chemical product calculator
- Basis
  - Cumulative CHL correlates well with the mass of chemical product *added* to a test per unit of strainer surface area
  - L* "superficial" loading, No explicit need for filtration

L* Development

- Evaluation of both strainer and vertical head loss test
  - Concept of L*
    - Based on grams of precipitate available to filter across a strainer surface area
    - Comparisons of HL data require viscosity and velocity adjustment
    - Allows comparison of strainer results to vertical head loss results
    - Incorporates deterministic tools in risk-informed application
- CHL investigated as a function of precipitate type
  - AlOOH induces largest CHL response per gram added (Argonne and UNM column tests)
- Reasonable conservatism provides tight bound to data
  - Remove declining or non-increasing head loss when chemicals are added

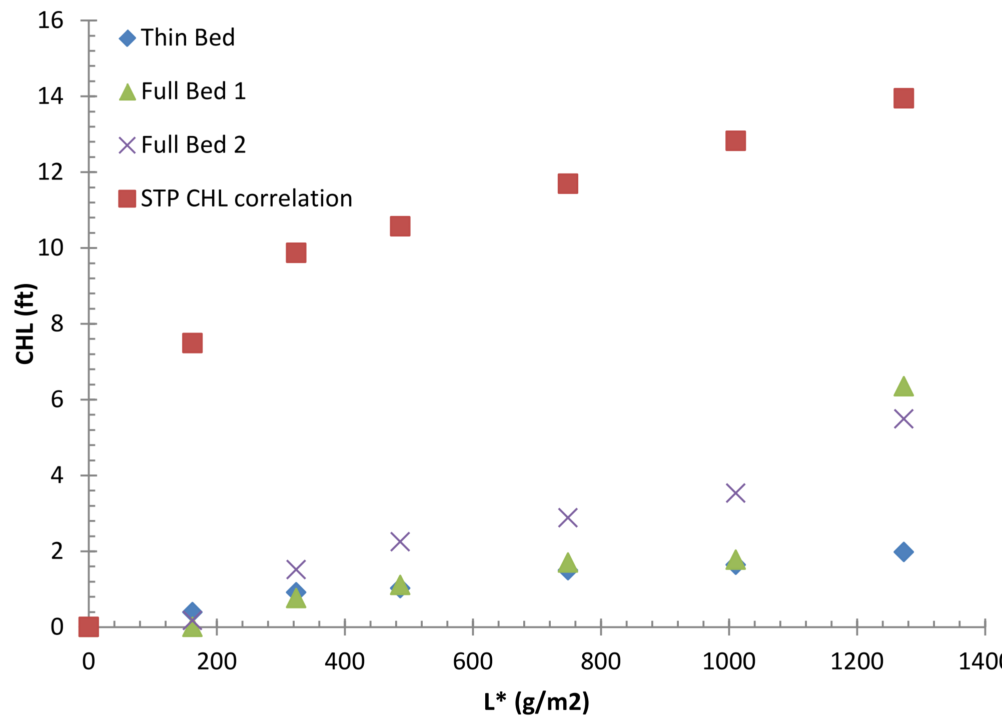
L* Correlation for one STP Strainer Test



- Monotonic increasing head loss under high 30-day chemical load
- ±25% uncertainty between strainer test replicates
- Correlation provides reasonably conservative CHL results compared to data

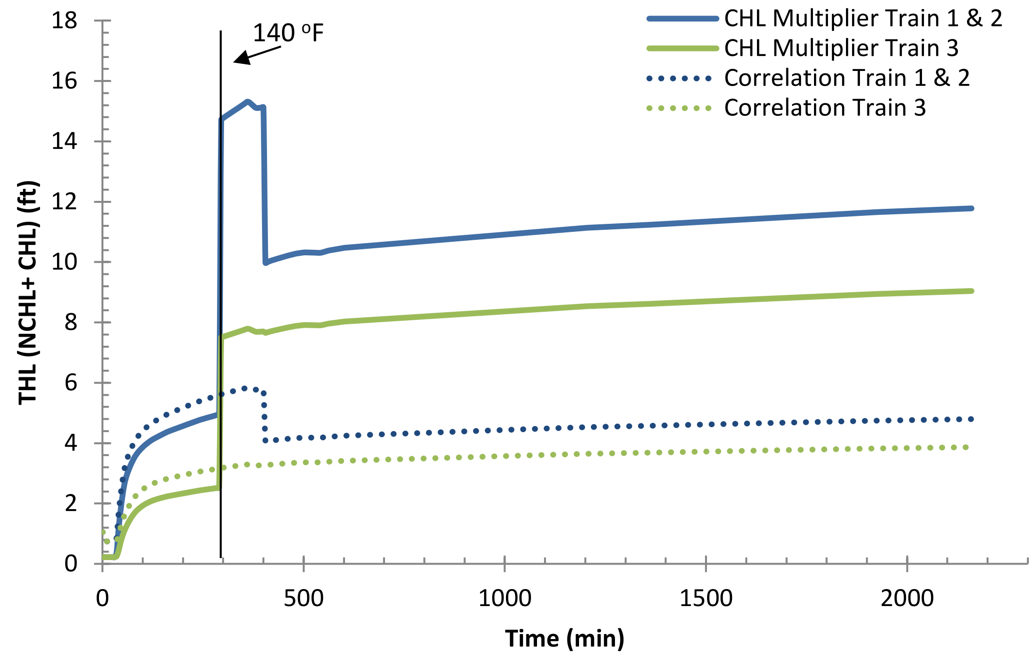
L* Evaluation Compared to Other Industry Strainer Tests

- STP L* correlation bounds typical thin bed and DBA CHL increase
- Additional evidence that STP L* correlation does not under estimate CHL



L* Compared to Multiplicative Chemical HL Factor

- 31” DEG break
  - CHL factor (solid lines)
    - Mean multiplier (3X)
  - L* Correlation (dot lines)
    - Largest measured CHLE Aluminum concentration
- LAR bounds likely prototypical CHL with reasonable uncertainty (x2)
  - Very slight underestimation initially caused by delayed temperature criterion



NCHL – nonchemical conventional head loss
CHL- chemically induced head loss
THL – total head loss

Conclusions of the L* evaluation

- Provides technical support for use of multiplicative CHL approach that is derived from strainer test data
  - Supports the position that multiplicative CHL factors do not underestimate risk
  - Identifies potential improvements to CHL factor approach (but would not affect risk)
    - Additive CHL rather than multiplicative may better preserve Small, Medium, Large correlations
    - Tighter correlation with L* for small breaks
    - Direct use of WCAP calculator for assumed continuous precipitate production rather than assumed onset temperature

Conventional Debris Head Loss

Conventional Debris Head-Loss Calculation

- Full bed compaction (65 lb_m/ft^3) to obviate controversy with compression model
  - Sets limit on bed thickness and composite porosity
  - Calculated using time-dependent inventory of particulate and fiber on the strainer
- Factor of 5 uncertainty bound consistent with observed variability between similar tests and facilities
  - Not dissimilar to treatment of other physical uncertainties
    - ZOI size, coatings failure, 30-day chemical inventory at 140°F
- STP LAR applies the modifications to the NUREG/CR-6224 formula

Available HTVL Data

#	Description	Assessment
Test 1	All Nukon added then all SiC	Possible initial strata with particulate infusion. Tends toward homogeneous over time
Test 2	Discrepancy b/t graphs and text description	Data value is indeterminant
Test 3	SiC then all Nukon then SiC	Particulate infusion and low fiber tends toward homogeneous. Much higher particulate to fiber ratio than Test 1
Test 4	Nukon and SiC added in constant proportion	12 small equal batches of fiber and SiC Should be homogeneous
Test 5	Nukon and Iron Oxide added together in constant proportion	12 small equal batches of fiber and iron oxide Should be homogeneous
Test 6	Nukon and Acrylic added together in constant proportion	12 small equal batches of fiber and acrylic Should be homogeneous
Test 7	Nukon and Tin added together in constant proportion	Should be homogeneous No measurements avail for tin Sv
Test 8	Mixed particles first, then Nukon – similar to ARL flume test (Ref. 15)	Should be homogeneous No meas'd Sv for tin, µTherm, Marinite Data not usable
Test 9	Like Test 8 but different order - Tin and Microtherm last	May have strata No meas'd Sv for tin, µTherm, Marinite Some Nukon+Acrylic only data available
Test 10	Nukon and Acrylic added together in constant proportion	Should be homogeneous
Test 11	Nukon and Acrylic added together in constant proportion	Should be homogeneous

ALION-REP-STP-8511-02, *South Texas Vertical Loop Head Loss Testing Report*. Revision 1 January 24, 2013

STP Strainer Tests (Feb 2008)

Test	Description	Results (ft-water)
Feb. Test 1	Clean Screen Head Loss	0.07
Feb. Test 2	Fiber only (debris introduced in drop zone)	0.3
Feb. Test 3	DBA (debris introduced in drop zone)	> 15
Feb. Test 4	DBA (non-chemical debris was introduced along the length of the flume prior to being filled with water)	8.4
Feb. Test 5	Reduced DBA (debris introduction same as Test 4 and fibrous debris quantities reduced by 35%)	7.1

0415-0100069WN / 0415-0200069WN. "South Texas Project Test Report for ECCS Strainer Performance Testing Feb 2008". Revision A. 11/24/2008

- All tests in February included walnut flour as a surrogate for epoxy
  - Later deemed a non-representative surrogate
- Test 3 was terminated prior to the addition of chemicals due to large head loss
- Tests 4 and 5 were conducted at lower temperatures (60°F, usually at 110°F) because modified debris introduction could not accommodate heat exchanger

STP Strainer Tests (July 2008)

- Used a WCAP-reduced ZOI size (later rejected)
- The test also allowed debris to settle
  - not preferred protocol for strainer qualification
- All debris was introduced at the drop zone.

Test	Description	Results (ft-water)
July Test 1	Clean Screen Head Loss	0.09
July Test 2	DBA (used to derive L* correlation)	8.8

0415-0100071WN / 0415-0200071WN. "South Texas Project Test Report for ECCS Strainer Testing July 2008". Revision A. 11/24/2008

- **Strainer Test Comparison**
  - All tests report the stabilized head loss at the end of the tests
  - All results reported at a similar flow rate and temperature except for Feb Tests 4 & 5.
    - Lower temperature (by approx 50 degrees) was not compensated

CASA Grande Maxima for Case 01 (all pumps running)

Description	Max (ft-water)
Clean Screen Head Loss	0.22*
Max Conventional Head Loss	8.2
Max Chemical Head Loss	154.9
Max Total Head Loss	161.9

- Modified correlation easily bounds all test results
- Modified correlation induces strainer failures
- Independent maxima reported from an ensemble of break scenarios (components not intended to add to total)

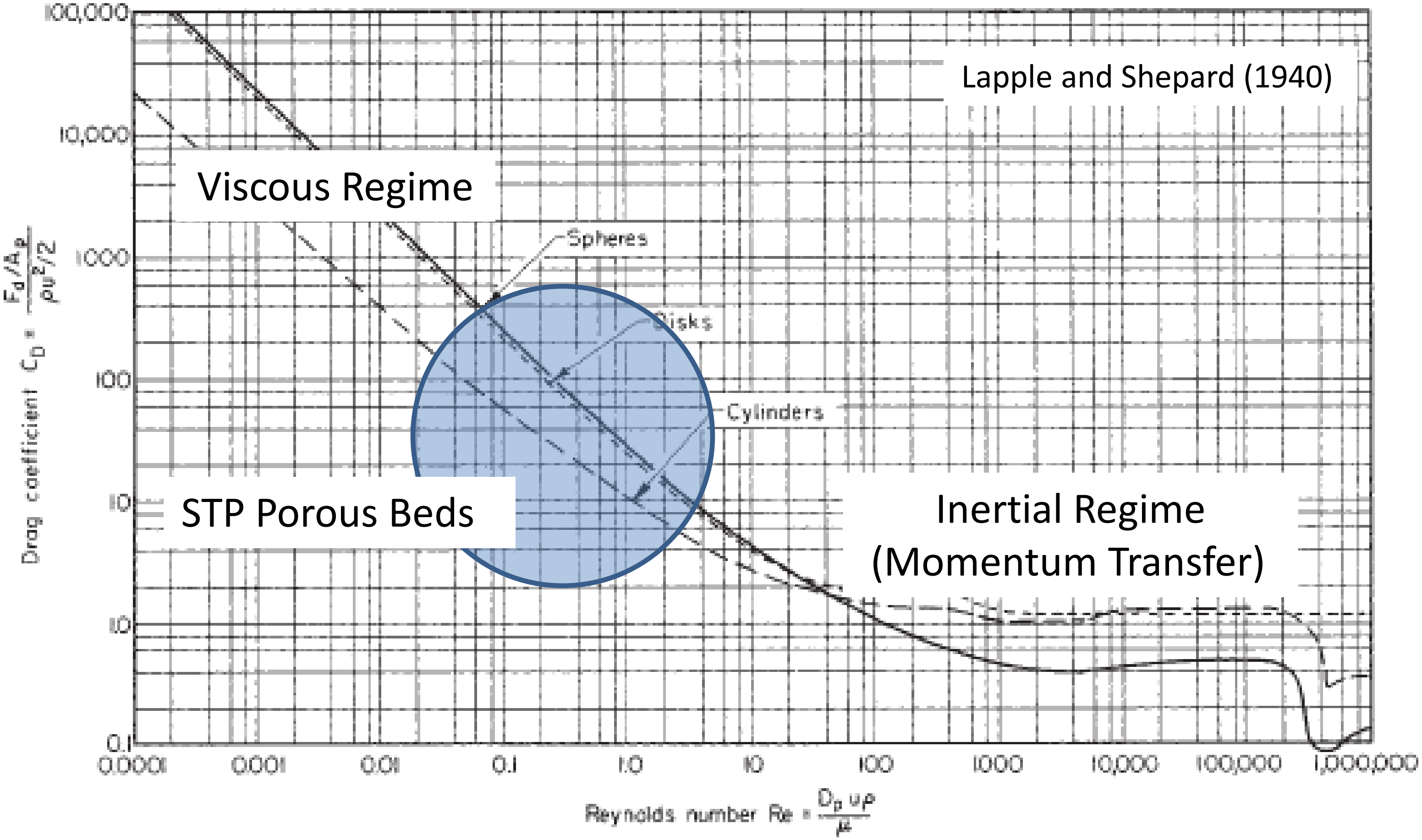
*Clean screen head loss should be 1.95'. Error was addressed in RAI response. Impact would be 18% increase in ΔCDF.

Purpose of VISTA Correlation

(Viscous-Inertial Shear-Transition-Adaptive)

- Independently supports use of modified NUREG/CR-6224
  - No change to LAR is proposed
- Addresses concerns with NUREG/CR-6224
  - Factorization of porosity (exponents of ε)
  - Uniform bed compression (now differential)
  - Limited range of test conditions (*Re* scaling)
  - Stratified bed configurations (case studies)

Re Scaling in Viscous/Inertial Transition



Classic experiments suggest that total hydraulic drag can be described by a low-order function of Reynolds number in the viscous/inertial transition.

VISTA Attributes

- Good agreement with HTVL test data
- Robust Reynolds number correlation confirms applicability of existing test data to STP
- Exponential drag law – (Reynolds 1883)
  - Preserves both theoretical limits (Raleigh 1892)
    - Stokes (viscous), Newton (inertial)
- "Adapts" to transition because coefficients are also fit as functions of *Re*
- Maximizes use of independent debris properties
- Results sensitive to bed compression/strata

Basic Equation

- Differential pressure gradient based on analogy to viscous shear stress
- Standard factorizations of hydraulic radius internal to porous media
- Empirical drag coefficient using Reynolds power law

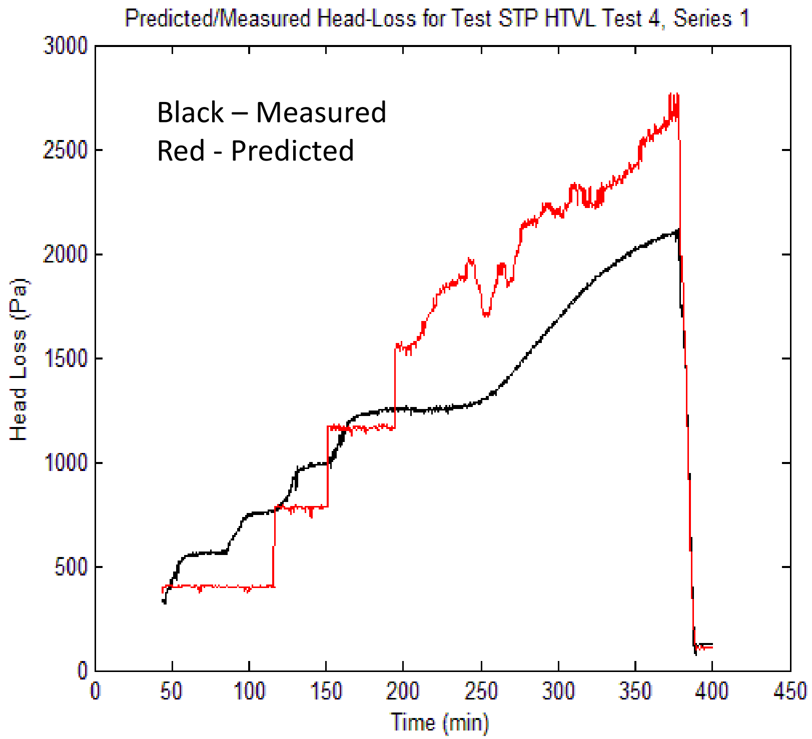
$$-\left(\frac{dP}{dz}\right) = \left[b\left(Re\right)Re^{m\left(Re\right)}\right]\left(\frac{1-\varepsilon}{\varepsilon^{3}}\right)S_{V}\rho w_{A}^{2}$$

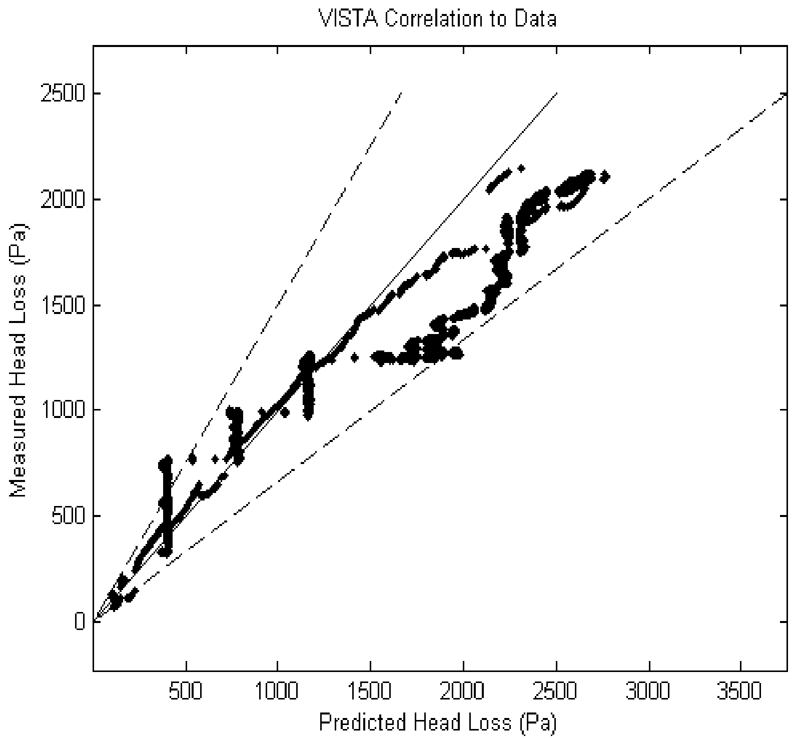
$$= b\left(Re\right)\left(\frac{\rho w_{A}}{\mu\left(1-\varepsilon\right)S_{V}}\right)^{m\left(Re\right)}\left(\frac{1-\varepsilon}{\varepsilon^{3}}\right)S_{V}\rho w_{A}^{2}$$

- Measurements of pressure drop in homogeneous beds used to find *b(Re)* and *m(Re)*
- NUREG/CR-6224 compression formula used for illustration

VISTA Blind Performance Comparison

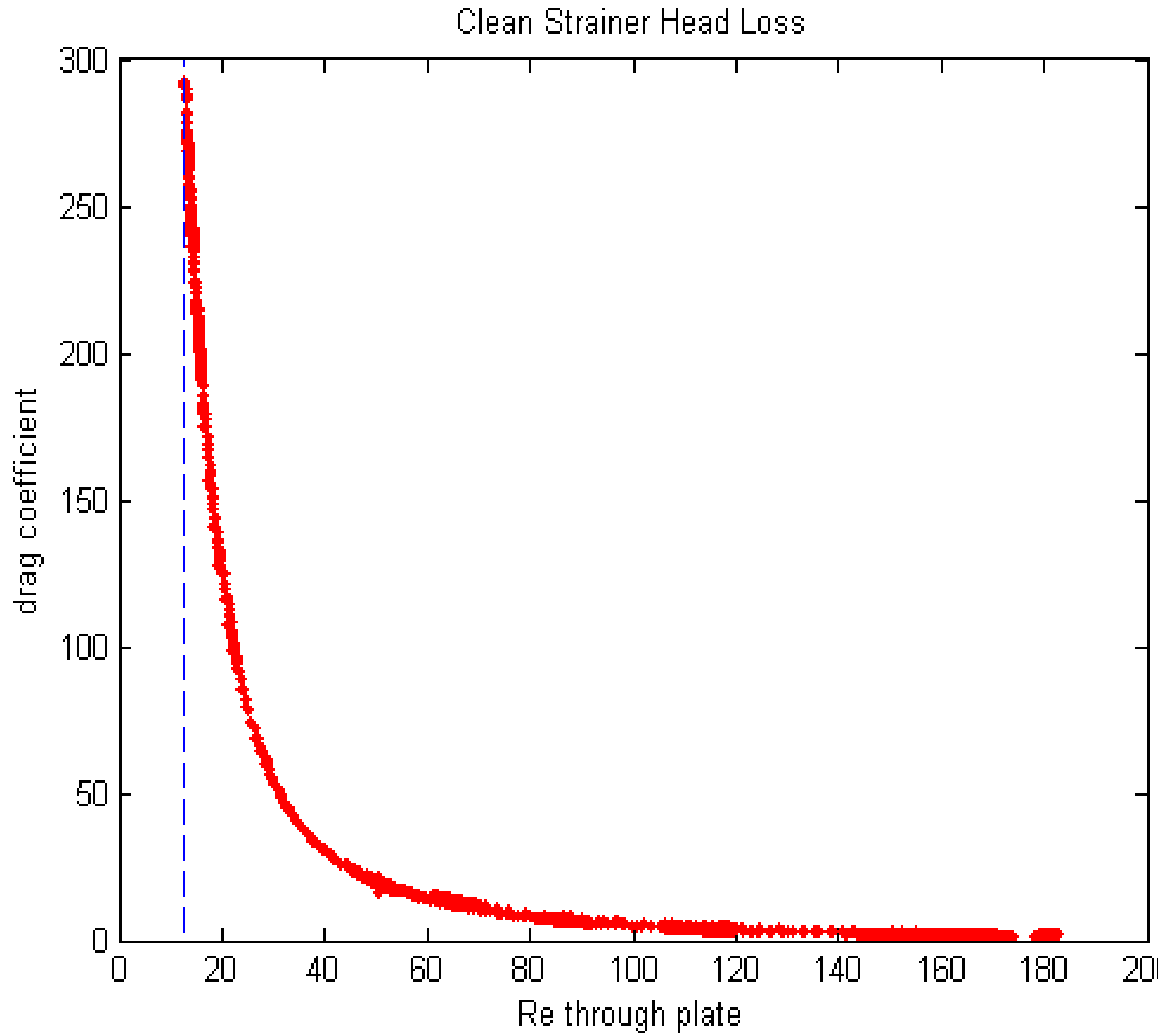
- Data from Nukon + Acrylic (Test 6) used to calibrate VISTA parameters
- Applied to Nukon + Silicon Carbide (Test 4) with ±50% agreement





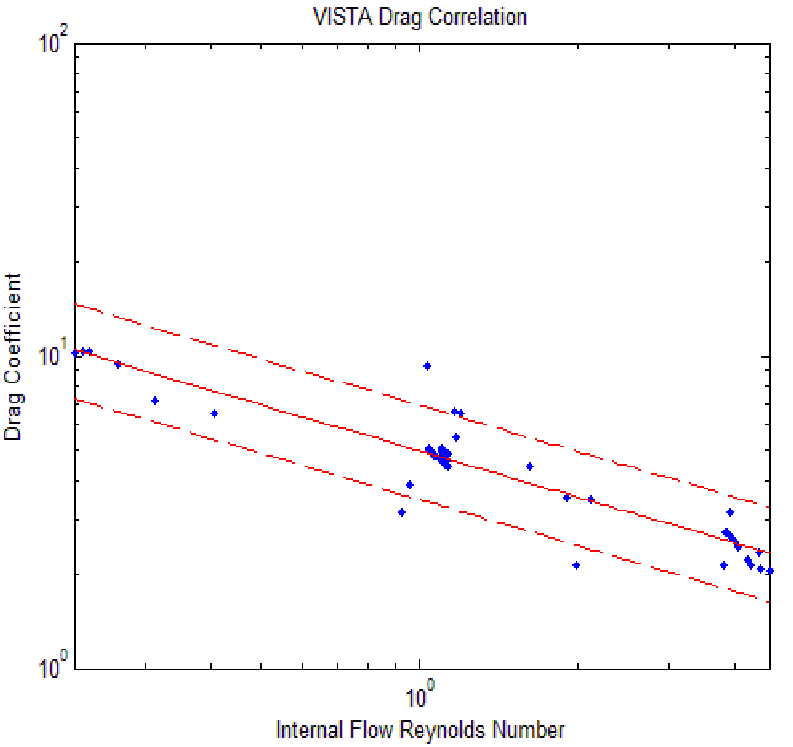
Clean Strainer Correlation

- 9 of 11 STP HTVL tests usable for *Re* correlation
- Clear evidence of *Re* power law
- ±15% agree for all data



Distribution of *Re* Conditions

- Internal *Re* from even a single HTVL test span two decades (figure for Test 6)
- Distribution of *Re* calculated for a suite of 600,000 CASA Grande scenarios spans .01 to 2.0



Break Size	S	M	L
Avg. Reynolds #	0.0237	0.0800	0.3105
Max Reynolds #	0.0748	0.2565	1.7480

VISTA Findings

- Bed configuration is the most sensitive remaining assumption
  - Uncertainty in spatial profile of porosity and surface area lead to largest discrepancy between prediction and measurement
  - Justifies STP assumption of maximum compaction
- Independent confirmation of measured head loss for STP Reynolds flow conditions confirms modified 6224 does not underestimate risk
  - Maximum bed compaction
  - Factor of 5 uncertainty measure

Dimensions of Uncertainty Analysis

- Parameter Uncertainty
  - Propagation of parameter distributions to ranges in risk
  - Investigated in sensitivity analysis report
    - Precipitation temp, debris quantities, filtration function, etc.
- Propagation Uncertainty (sampling error)
  - Nonuniform LHS sampling achieves variance reduction
  - Batch convergence of variance assures adequate sampling
- Model Uncertainty
  - L* and VISTA support choice of head-loss model and model uncertainty bound
    - Head loss prediction is sensitive to bed configuration – LAR use of bed compaction reduces model uncertainty (x2)
    - LAR calculations do not underestimate head loss
    - LAR approach has a reasonable uncertainty bound without introducing arbitrary conservatism

Agenda

- Introduction – Mike Murray
- Progress since last ACRS – Ernie Kee
- General Overview of PRA Process Flow – Ernie Kee
- CASA Grande interface with the PRA – David Johnson
- Thermal Hydraulic Analyses – Rodolfo Vaghetto
- In-vessel effects – Ernie Kee/Bruce Letellier
- LOCA Size/Frequency and Break Selection – David Morton/Bruce Letellier
- Treatment of Chemical Effects, including relevant testing – Kerry Howe
- Head loss, including relevant testing – Bruce Letellier
- **Specific Examples (including debris generation and transport and coatings) – Bruce Letellier/Dominic Munoz**

Topics for Discussion

- Role of CASA Grande in scenario analysis and risk quantification
- Calculation elements of each break scenario
- Examples of success/failure scenarios

Role of CASA Grande

Role of CASA Grande in STP LAR

- Automates plant-specific hand calculations of debris generation/transport/accumulation and supports rigorous uncertainty propagation
- Complements PRA by quantifying conditional probabilities of ECCS failure for Small, Medium, Large breaks by several failure modes induced by GSI-191 phenomena
  - "First" threshold exceedance fails the scenario
- Quantitative insights gained on
  - accident progression timing/sequence
  - risk attribution (dominant break locations and attributes)
- Licensed from Los Alamos National Laboratory by Alion Science and Technology for commercial development
  - Software Quality Assurance review to meet Appendix B
  - All enhancements revert back to LANL for government use

CASA Grande Attributes

- Nonuniform Latin Hypercube Sampling (LHS) of break sizes and other physical parameters
  - Emphasis on large breaks to elicit failure modes (no bias)
  - e.g., time to HL injection, filtration parameters, pool volume, etc
- Batch replication for variance tracking
  - Samples probability density functions (pdf) for ~50 variables
  - Practical run times for several million scenarios
- Auto calculation of debris volumes for spherical and hemispherical ZOI using CAD geometry
- Solves time-dependent debris accumulation based on EOP-driven pump flow rates and filtration function
  - Plant damage state defines available pumps
- Accepts pool temperature profiles and boil-off rate
- Integrates physical models and propagates parameter uncertainty into conditional failure of ECCS

Calculation Elements

Scenario Failure Thresholds

Threshold	Failure Condition
1. strainer ΔP ≥ NPSH margin	Any time step, any single strainer
2. strainer ΔP ≥ structural margin	Any time step, any single strainer
3. strainer void fraction ≥ 0.02	Any time step, any single strainer
4. core fiber load ≥ 7.5 g/FA cold-leg-break fiber limit for BAP	Any time step prior to HL injection. Cumulative from all strainers
5. core fiber load ≥ hot-leg-break fiber limit for BAP	Not applied. No boric acid concern for HL breaks
6. core fiber load ≥ cold leg break fiber limit for flow blockage	Not applied. Adequate cooling demonstrated for full blockage
7. core fiber load ≥ hot leg break fiber limit for flow blockage	Not applied. Adequate cooling demonstrated for full blockage

Debris Generation

- Every scenario has a unique debris combination
- Failed unqualified coatings
- ZOI-damaged qualified coatings based on 31-in. break
- Spherical ZOI for DEGB and hemisphere, random azimuth for tears
  - Insulation ZOI based on NEI-04-07 damage radii
  - Coatings ZOI based on WCAP-16568
  - CASA Grande auto calculation of insulation debris volume and size by type

Debris Transport

- Single insulation debris transport fraction applied to all scenarios
  - Fractions based on transport with spray with minimal hold up on gratings
- Early arrival insulation debris placed in pool at t=0
  - Actual transport history compressed
  - Fill-up transport fraction assigned to strainer prior to recirculation
- All failed coatings placed in pool in first 10-min time step

Debris Transport

- Explicit time-forward integration used to track inventory: (1) in pool, (2) on strainer, (3) on core
- 100% particle/chemical retention on strainer
  - Yet, core limit based on testing with particulate/chemicals
- Strainer penetration/filtration model calibrated to strainer test data
  - Treats load dependent filtration efficiency and shedding
  - Controls core failure potential
- 100% fiber retention on core
- Debris split to spray (no internal lag time)
- Debris bypass around core (no internal lag time)

NPSH Calculation

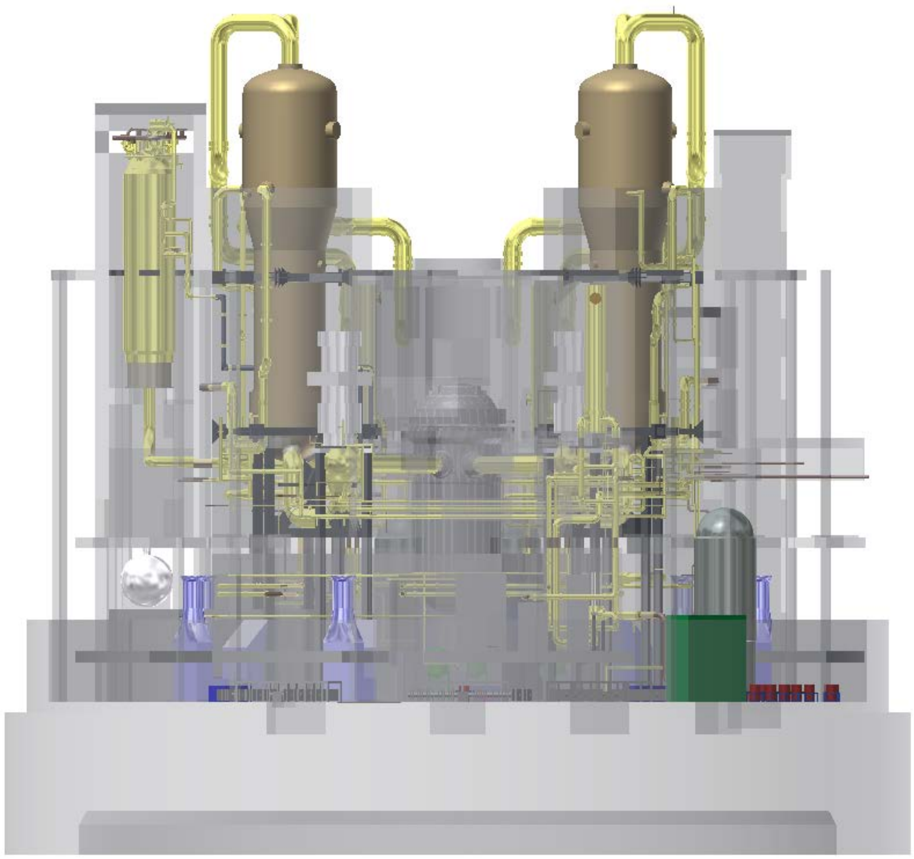
- Standard plant geometry
- No credit for containment over pressure
  - $T \geq 212F$, $P_{cont} = P_{sat}$, $T < 212F$, $P_{cont} = P_{atm}$
- Time-dependent temperature and flow rate applied to each operating pump
- Failure declared if *any* pump loses required head

Examples of Success and Failure

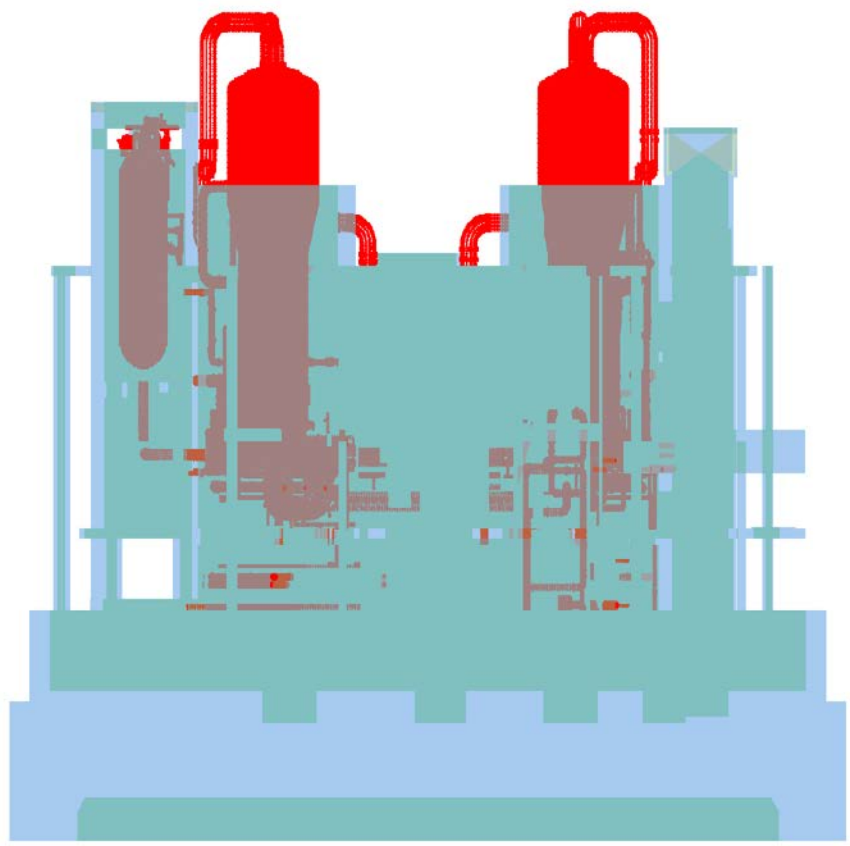
Role of CAD in STP LAR

- Introduces important plant-specific spatial relationships
- Accurate location/size of break locations
- Target inventory in assumed ZOI
  - Insulation and coatings
- Clipping ZOI by robust barriers
- Transport logic accounting for break location, debris type/size relative to gratings and sumps
- Containment flooding level
- CFD computation domain
- CAD developed under QA program to support additional applications
  - Concrete, steel, equipment, insulation
  - Drawings, photographs, walk downs

CASA Grande Examples



CAD Representation



CASA Grande Representation

CASA Grande Examples

- Three examples were investigated to illustrate the CASA Grande process at a high level
- These three examples were chosen from a list of the top contributors to failure probability
- All examples investigated were large DEGB LOCAs
- Examples were selected from base case where all pumps are considered operational

CASA Grande Examples

- Three examples chosen from weld “31-RC-1402-NSS-RSG-1D-ON-SE”. One success, one sump failure, and one in-vessel failure at this location.

Location	% Contrib	Success	Sump	Vessel
29-RC-1201-RSG-1B-IN-SE	26%	1	24	0
29-RC-1401-NSS-RSG-1D-IN-SE	25%	4	21	0
29-RC-1101-NSS-RSG-1A-IN-SE	16%	3	22	0
29-RC-1201-RSG-1B-IN-SE	16%	2	23	0
31-RC-1402-NSS-RSG-1D-ON-SE	5%	2	13	10
31-RC-1102-NSS-RSG-1A-ON-SE	5%	2	12	11
31-RC-1202-NSS-RSG-1B-ON-SE	3%	1	9	15
31-RC-1202-NSS-RSG-1C-ON-SE	2%	0	14	11
31-RC-1102-NSS-4	~	4	11	10
31-RC-1102-NSS-8	~	1	11	13
31-RC-1102-NSS-9	~	2	12	11
31-RC-1402-NSS-9	~	8	6	11

CASA Grande Examples
Debris Generation (Insulation)

- Three types of insulation analyzed in STP CASA Grande evaluation.
  - Microtherm 28.6 ZOI (Assumed similar to Min-K ZOI from NEI 04-07)
    - Destroyed as fines with mass fractions
      - 3% fiber filament
      - 58% SiO_2 particles
      - 39% TiO_2 particles
- Nukon and Thermal-Wrap destruction based of Alion test report
  - Destruction happens in three sub-zones, with a max destruction zone of 17D
  - Each zone contains percentages of destruction sizes: fines , small pieces, large pieces , and intact blankets
  - Major equip: SG, RCP, Pressurizer offer no shielding

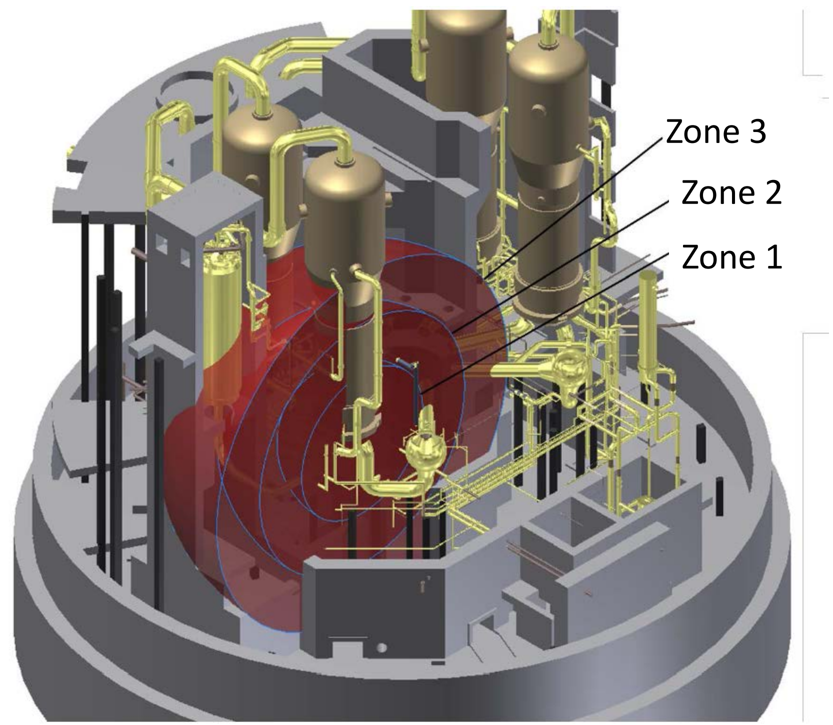
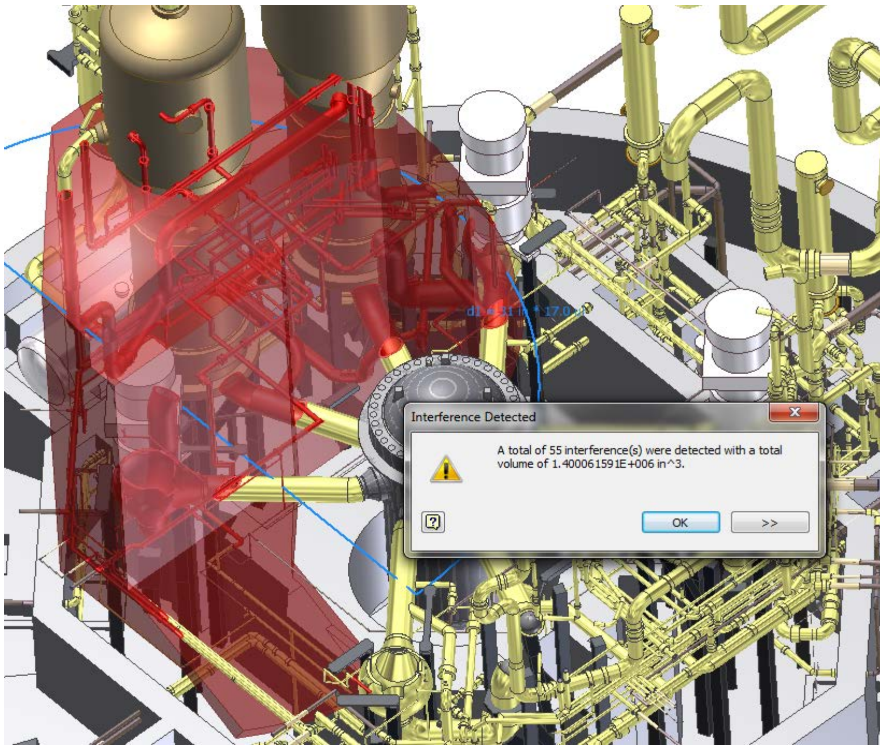


Figure 5.4.4 – Illustration of sub-zones used for fiberglass debris size distribution

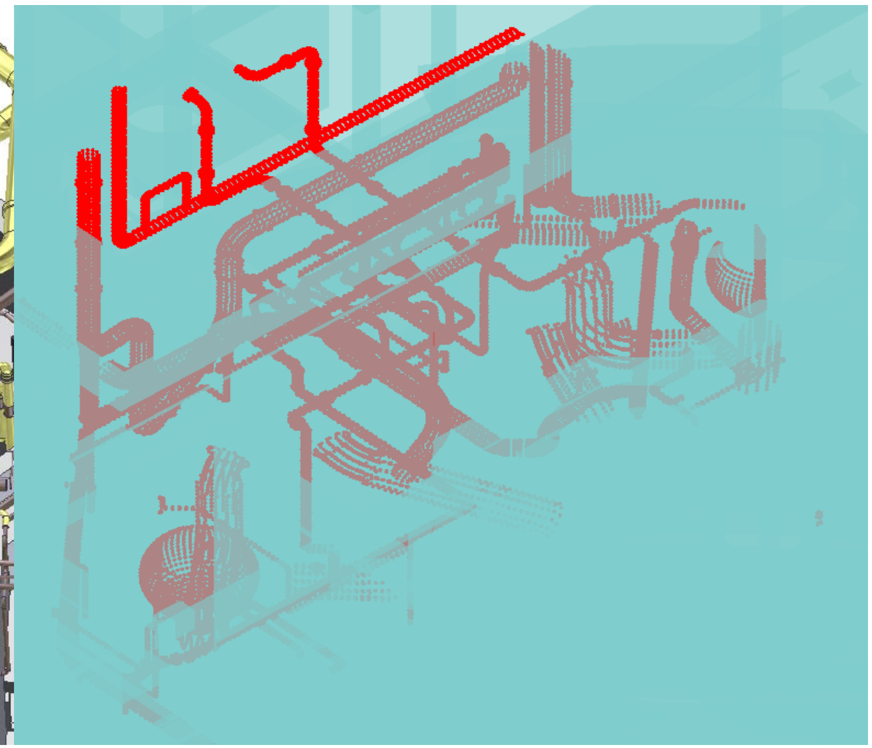
CASA Grande Examples

Debris Generation (insulation)

17D Nukon Insulation CAD and CASA Grande Interference on Crossover Leg 31-RC-1402 Weld NSS-RSG-1D-ON-SE



CAD Representation



CASA Grande Representation

Interferences done by hand in the CAD model and by CASA Grande numerical analysis produce 81.02 ft^3, and 87.24 ft^3 of destroyed Nukon insulation respectively. Numerical assumptions such as double counting for insulation at tee joints give slightly higher values in CASA Grande. This gives a 7% difference between CAD and CASA Grande calculated volumes.

CASA Grande Examples
Debris Generation

Because both of the breaks (Failure and Success) at the Crossover Leg weld are DEGB, their ZOI destroyed insulation quantities are the same.

Break on Crossover Leg 31-RC-1402 at Weld NSS-RSG-1D-ON-SE			
LDFG (Nukon+ThermalWrap)	CASA Volume Generated (ft^3)	CAD Volume Generated (ft^3)	% Difference
Fines (Individual Fibers)	264	257	2.7
Small Pieces (< 6" on a Side)	871	849	2.6
Large Pieces (> 6" on a Side)	418	405	3.2
Microtherm	0.711	0.0129	192.9

CASA Grande Examples

Debris Generation (Qualified Coatings Quantities)

- Qualified Coatings in containment assigned single bounding values for CASA Grande analysis
  - Qualified Epoxy
    - 105 lbm from Alion calculation performed in CAD environment
    - WCAP-16568, 4D ZOI used for all epoxy coatings
  - Qualified Zinc
    - 39 lbm destroyed from Alion calculation performed in CAD environment
    - WCAP-16568, 4D ZOI used for all IOZ coatings

CASA Grande Examples

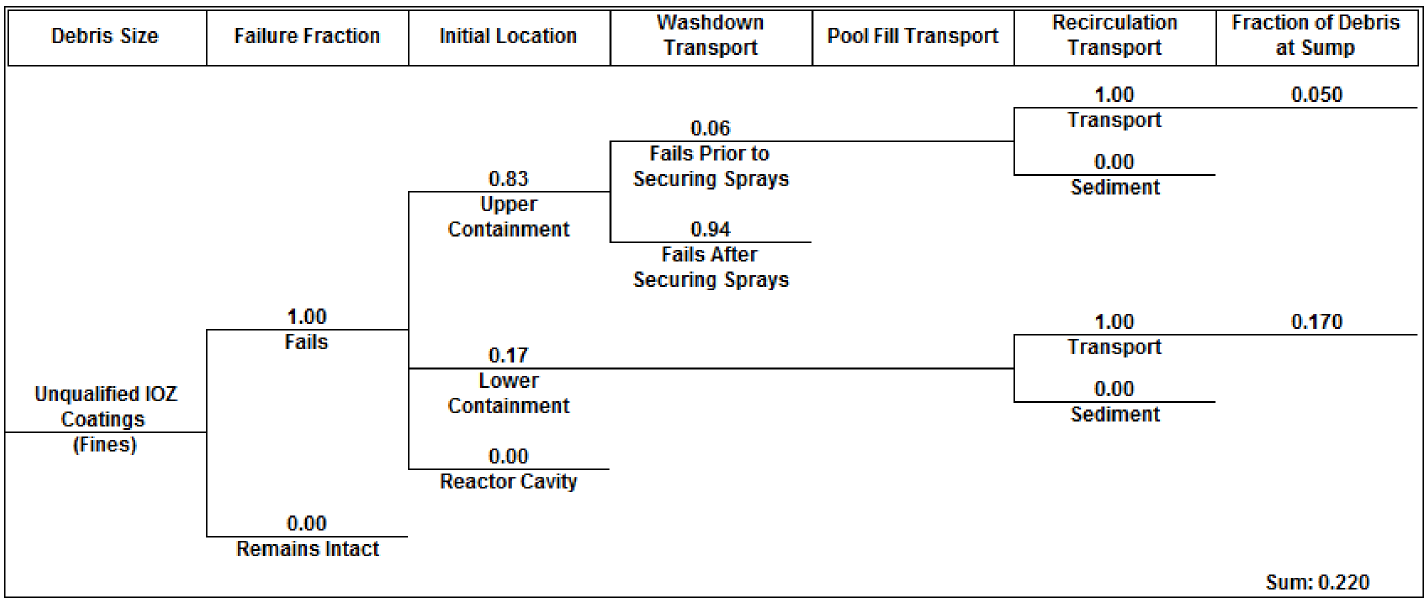
Debris Generation (Unqualified Coatings Quantities)

- **Unqualified Coatings**
  - **All damaged unqualified coatings introduced to pool in first time step**
  - **Unqualified Epoxy**
    - **Total amount in containment 1905 lbm**
    - **Failed epoxy is binned into size ranges determined from testing**
    - **83% of unqualified epoxy is in the reactor cavity and does not transport**
  - **Unqualified IOZ, Alkyd, and Baked Enamel**
    - **Total amount in containment 369 lbm, 271 lbm, and 267 lbm, respectively**
  - **100% of unqualified coatings in lower containment fail *and* transport**
  - **6% of unqualified coatings in upper containment fail/transport**

CASA Grande Examples

Debris Generation (Unqualified Coatings Quantities)

- **Unqualified IOZ example (369 lbm total in containment)**
  - **IOZ, Alkyd, and Baked Enamel were treated in this manner with their respective logic tree from LAR Encl. 4-3**



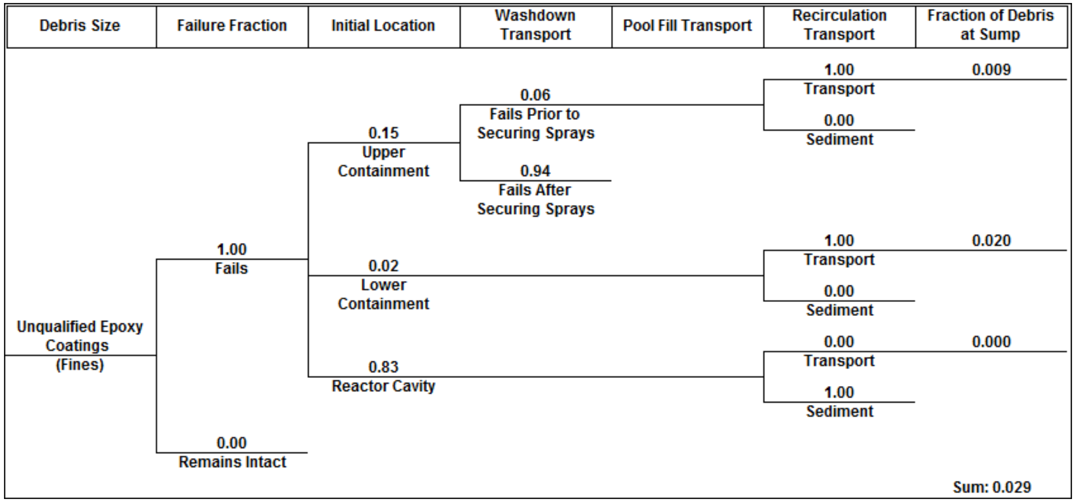
Upper Cont. Transport Lower Cont. Transport

$$369lbm * 1 * 0.83 * .06 * 1 + 369lbm * 1 * 0.17 * 1 = 81.1\ lbm$$

CASA Grande Examples

Debris Generation (Unqualified Coatings Quantities)

- **Unqualified Epoxy example (1905 lbm total in containment)**
  - **83% of unqualified epoxy is in the reactor cavity and cannot transport**
  - **All epoxy fails into size distribution by mass (fine 12.3%, fine chip 37.2%, small chip 9.4%, large chip 20.5%, and curled chip 20.6%)**
  - **Delamination of unqualified epoxy sampled between 50 and 100%**



Upper Cont. Transport

Lower Cont. Transport

$$(lbm\ Sampled) * 1 * 0.15 * .06 * 1 + (lbm\ Sampled) * 1 * 0.02 * 1 = lbm\ Transported$$

CASA Grande Examples

Debris Generation (Unqualified Coatings Quantities)

- **Unqualified Coatings Summary**

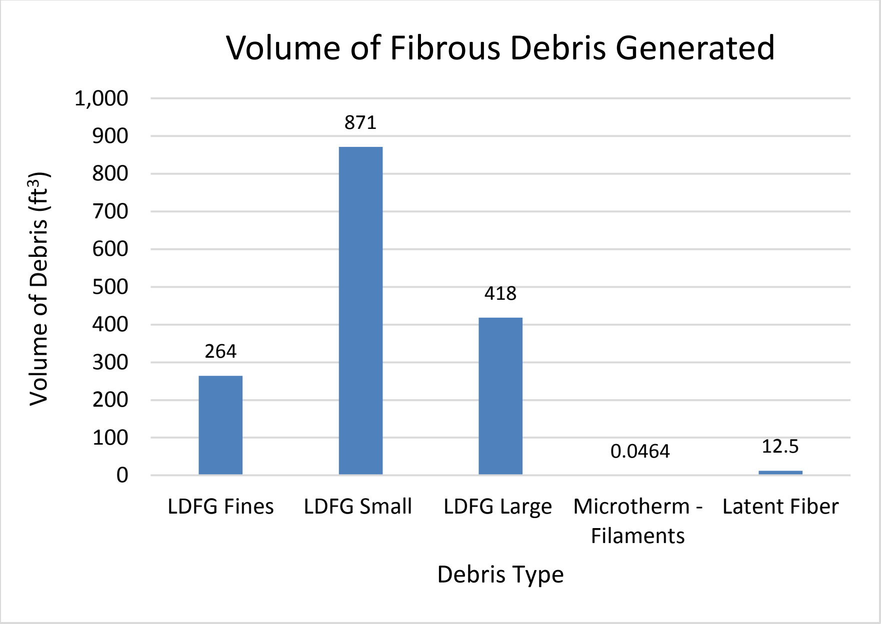
Type	Amount in Containment lbm	Percentage / Mass (lbm) Upper Containment		Amount in Pool (lbm) Example 1	Amount in Pool (lbm) Example 2	Amount in Pool (lbm) Example 3
IOZ	369	83%	306	81.1	81.1	81.1
Alkyd	271	54%	146	133	133	133
Baked Enamel	267	0%	0	267	267	267
Epoxy Fines	234	15%	35	6.60	4.92	4.36
Epoxy Fine Chips	709	15%	106	7.71	5.53	5.60
Epoxy Small Chips	180	15%	27	0.00	0.00	0.00
Epoxy Large Chips	391	15%	59	0.00	0.00	0.00
Curled Chips	391	15%	59	11.0	9.32	9.72
Epoxy Total	1905	15%	286	25.4	19.8	19.7

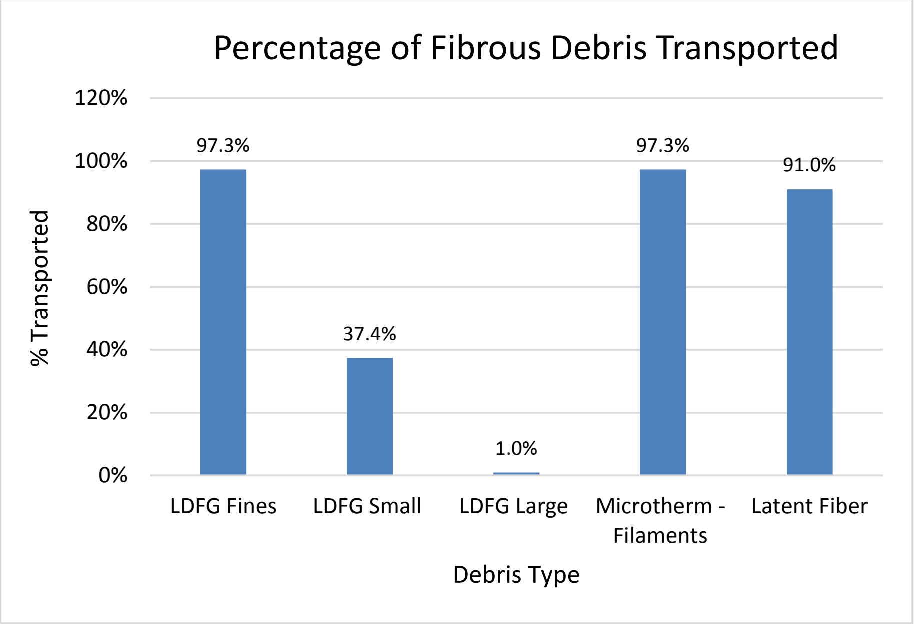
- Composition of particulates affects composite debris properties in the bed

CASA Grande Examples

Debris Recirculation Transport (Fibrous Debris)

- Because the three examples were from the same large DEGB LOCA the same amounts of fibrous debris were transported. Generated amounts are shown for comparison.





CASA Grande Examples

Sampled User Inputs

- The table below shows sampled values and corresponding, conditional sampled percentiles for a few of these probabilistic inputs

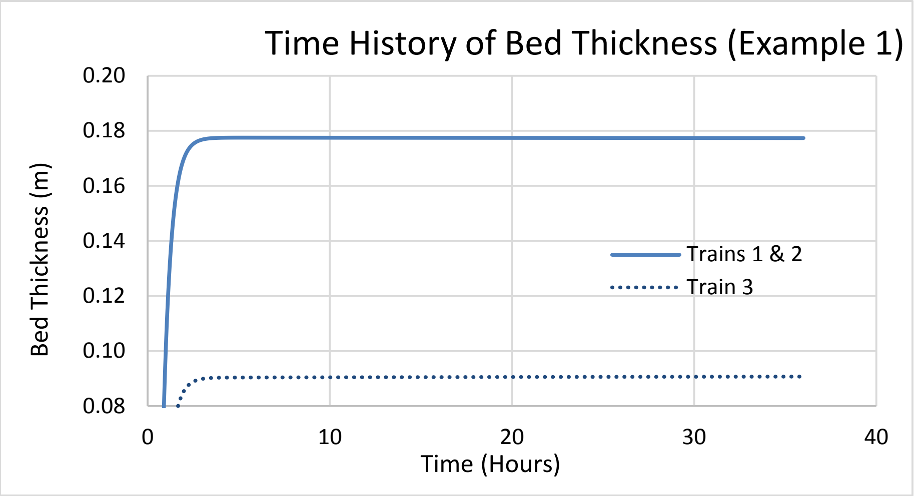
Input Parameter	**Example 1 (Success)**	**Example 2 (Sump Failure)**	**Example 3 (In-Vessel Failure)**	Units
Hot/Cold Leg Break	Cold Leg	Cold Leg	Cold Leg	-
Time One Spray Secured	20.0	15.0	15.0	Minutes
Time All Sprays Secured	405.0	395.0	395.0	Minutes
Hot Leg Injection Time	345.0	355.0	350.0	Minutes
Chemical Temperature	132.9	136.5	139.1	°F
CHL Factor	**1.7**	**5.0**	**1.1**	**None**
CHL Factor Time	470.0	405.0	310.0	Minutes
CHL Factor Time	7.8	6.8	5.2	Hours
Pool Volume	56529.0	58866.0	45972.0	ft3
Containment Spray Rate	2223.0	2148.7	2227.2	GPM
Fraction of Sheddable Debris	**0.0209**	**0.0180**	**0.0096**	**None**
Shedding Flow Fraction	**0.0128**	**0.0151**	**0.0386**	**1/min**
Filter Efficiency Per Gram	**0.0285**	**0.0259**	**0.0119**	**1/g**
Filter Efficiency Cut Point	**102.5**	**101.5**	**96.3**	**g**
Initial Filter Efficiency	**0.6639**	**0.6649**	**0.6664**	**None**
Filter Efficiency Match Point	**1**	**1**	**1**	**None**
Filter Exponential Rate Constant	**0.0509**	**0.0560**	**0.0636**	**1/g**

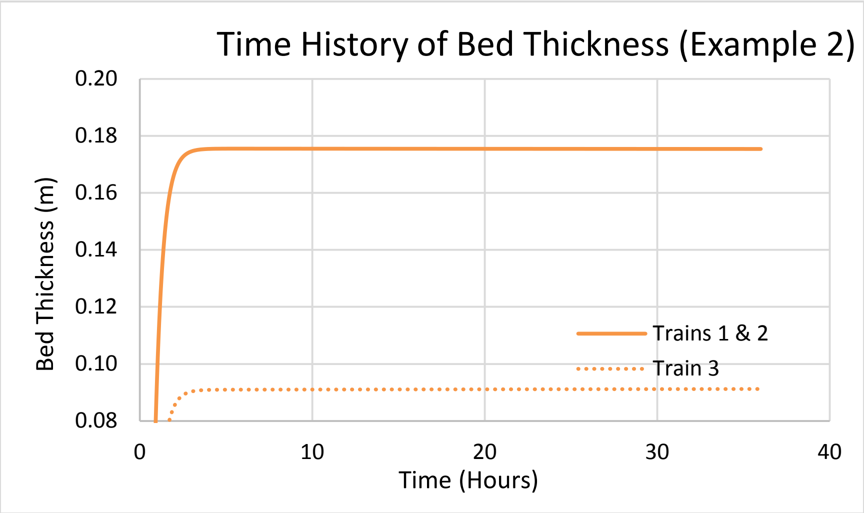
Note that inputs are sampled randomly for each simulated break.

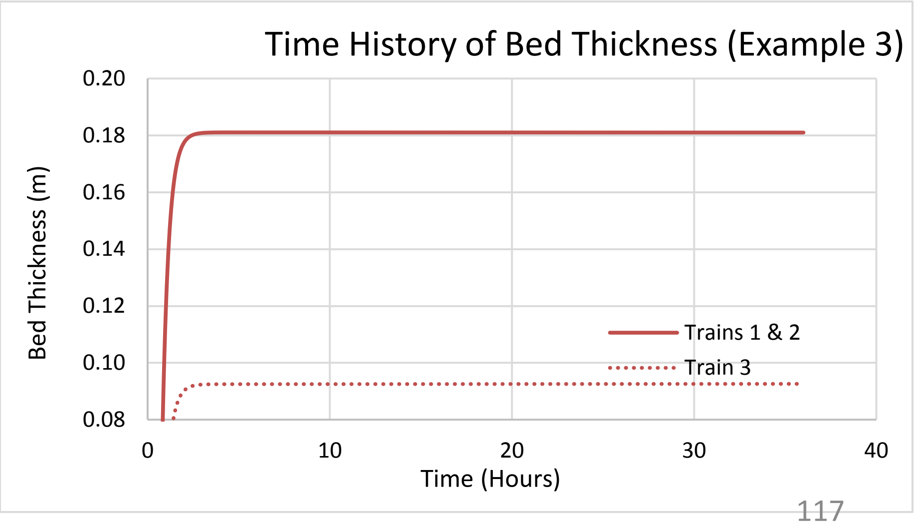
CASA Grande Examples

Results (Debris Bed Thickness)

- Example 1 (Success)
- Example 2 (Sump Failure)
- Example 3 (In-Vessel Failure)







CASA Grande Examples

Results (NPSH Margin)

- The $NPSH_M$ margin was calculated at each time step as the difference of $NPSH_A$ available and $NPSH_R$ required.

$$NPSH_A(t) = \frac{P_{cont}(t)}{\rho(t)g} + h_{elev} - h_{piping} - \frac{P_{vap}(t)}{\rho(t)g}$$

$$NPSH_R(t) = NPSH_{R(man)} \times \left(1 + 0.5\alpha_p(t)\right)$$

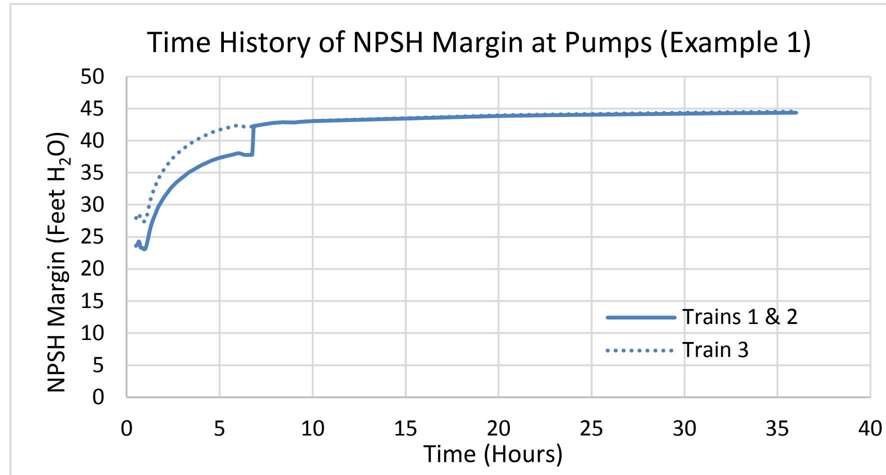
$$NPSH_M(t) = NPSH_A(t) - NPSH_R(t)$$

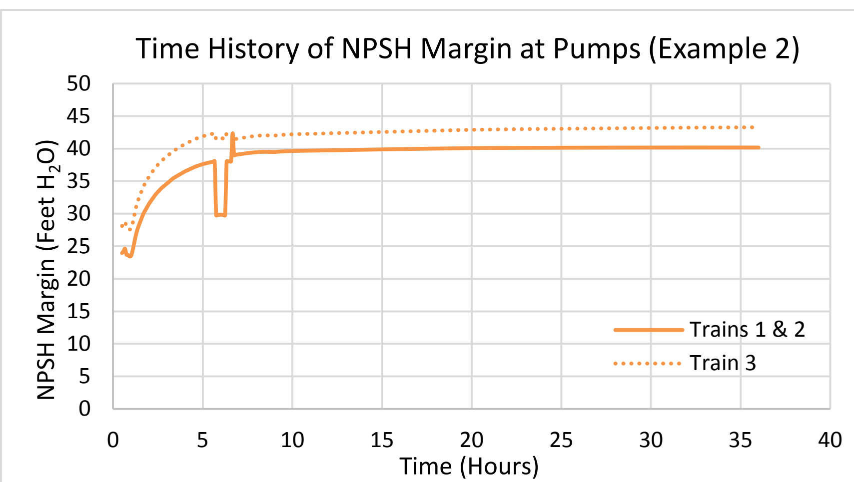
P_{cont} = Containment Pressure
h_{elev} = elevation from top of pool to pump
h_{piping} = piping major and minor
α_p = void percentage at pump losses
$NPSH_{R(man)}$ = NPSH required from manufacturer testing

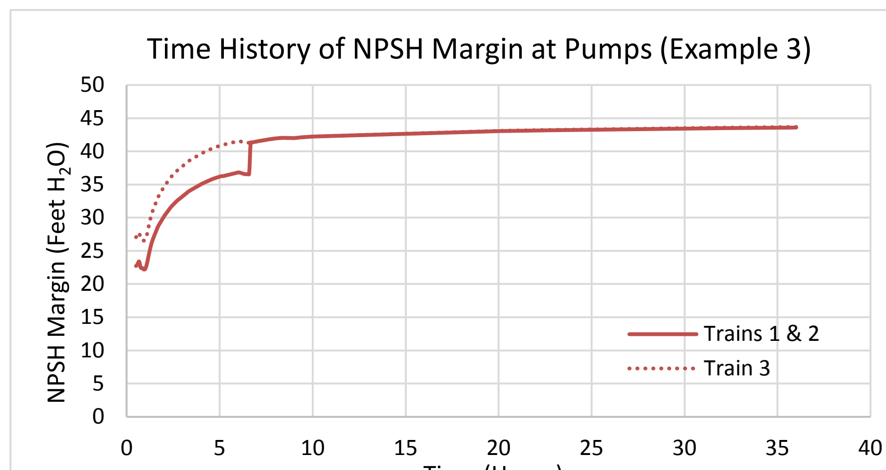
CASA Grande Examples

Results (NPSH Margin)

- Example 1 (Success)
- Example 2 (Sump Failure)
- Example 3 (In-Vessel Failure)







CASA Grande Examples

Results(Head Loss)

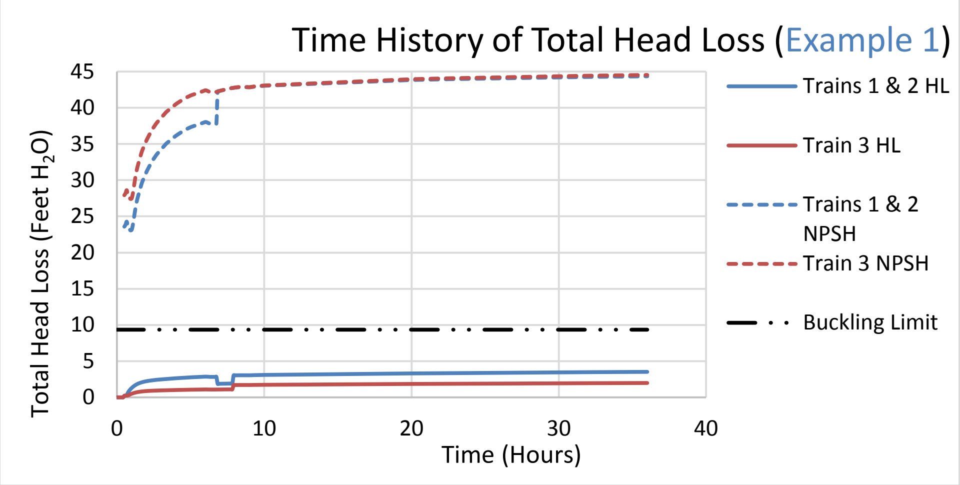
- Total head-loss is a combination of clean strainer, conventional debris (with uncertainty bound), and chemical head-loss contributions.
  - **Where**
    - ΔH_{DB} is conventional debris head-loss
    - M is the uncertainty bound on conventional debris head-loss (≥ 1)
    - B_{CE} is the chemical head-loss factor
    - ΔH_{CS} is the clean strainer head-loss

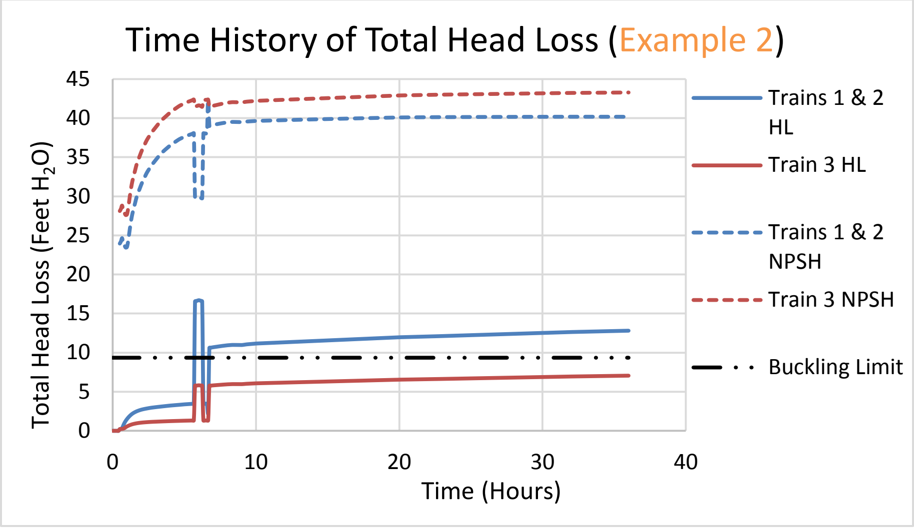
$$\Delta H_S = \Delta H_{CS} + \Delta H_{DB} \cdot M \cdot B_{CE}$$

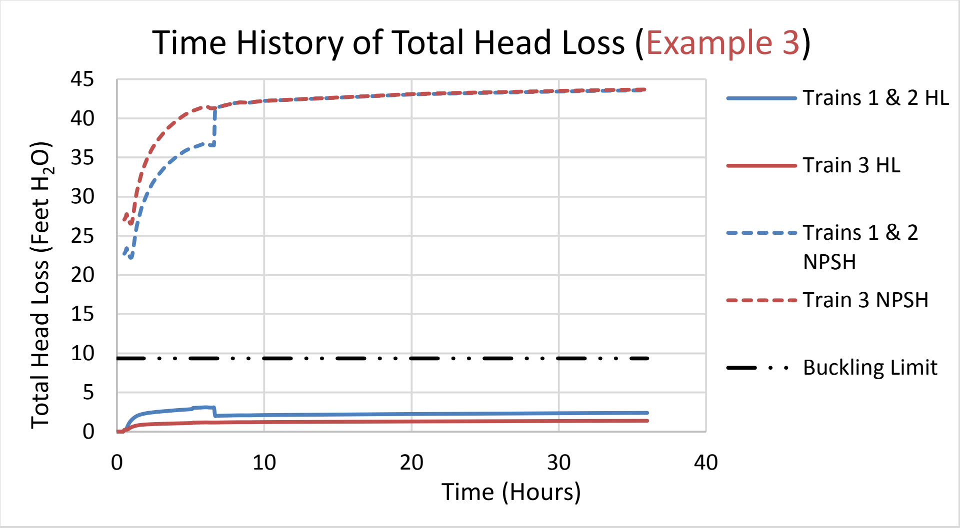
CASA Grande Examples

Results (Head-Loss Vs. Buckling and $NPSH_M$)

- Chemical Head-Loss Time 470 mins
  Chemical Head-Loss factor 1.66 (Example 1)
- Chemical Head-Loss Time 405 mins
  Chemical Head-Loss factor 5.02 (Example 2)
- Chemical Head-Loss Time 310 mins
  Chemical Head-Loss factor 1.05 (Example 3)







CASA Grande Examples

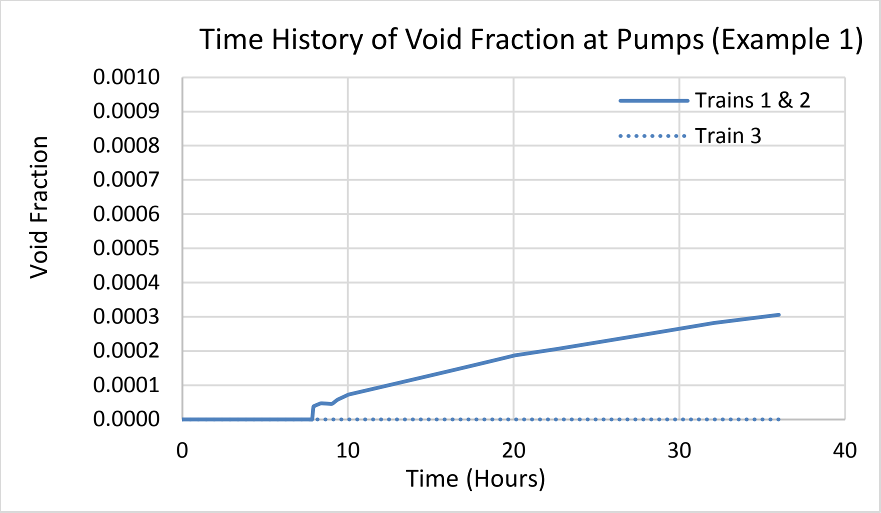
Results (Void Fraction)

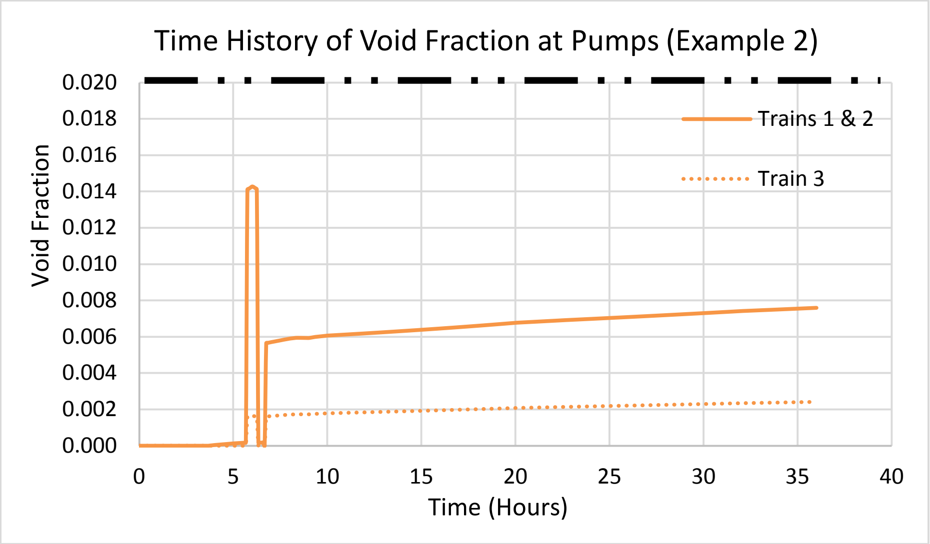
- Air release at the strainer was calculated using Henry's law.
  - Void fraction (α) is defined as the ratio of volumetric flow rate of air release to the sum of the volumetric flow rate of liquid and air release at the strainer
  - The total void fraction at each strainer was applied to each pump in connection with that strainer. The void fraction was not split by flow.
  - The Regulatory Guide 1.82 suggested value of 2% for void fraction at pump inlet is used to enforce criteria for failure by air ingestion
    - Criterion is applied at the *strainer*

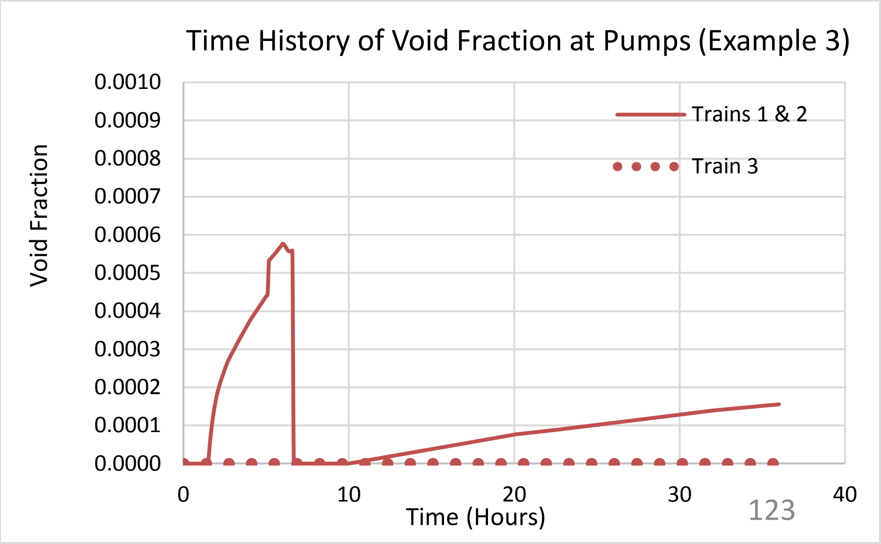
CASA Grande Examples

Results (Void Fraction)

- Example 1 (Success)
- Example 2 (Sump Failure)
- Example 3 (In-Vessel Failure)
- Void Limit







CASA Grande Examples

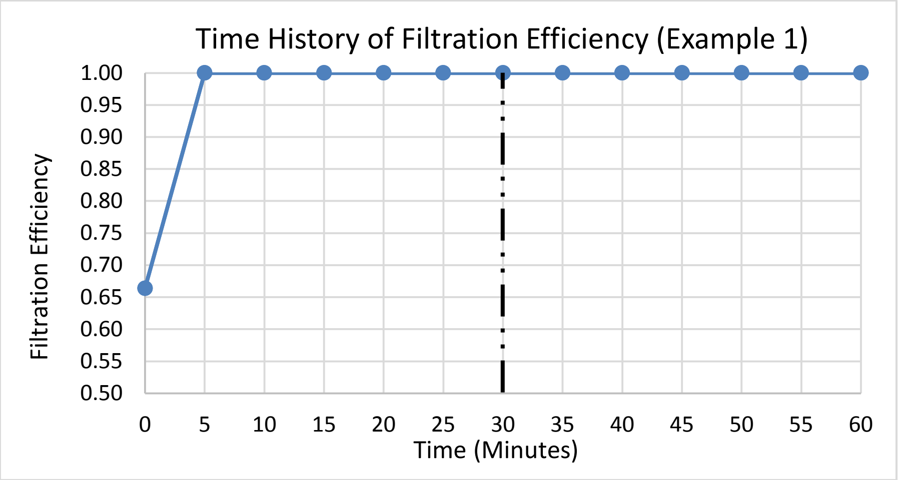
Results (Fiber Penetration and Boron Fiber Limit)

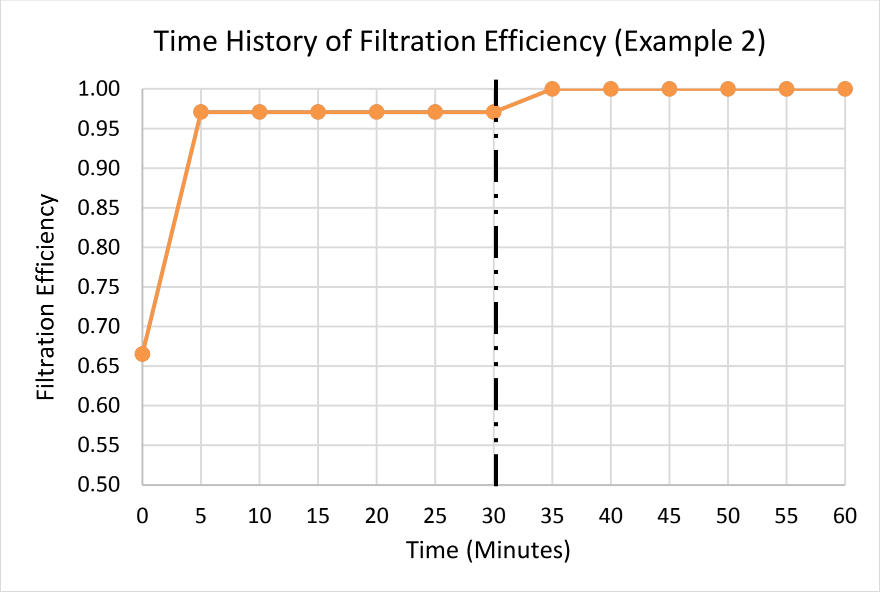
- Uncertainty in fiber penetration in CASA Grande is introduced by sampling fiber penetration/filtration parameters
  - These sampled parameters are used with correlations to STP strainer testing to find filtration efficiency, and shedding rate
  - Debris bed thickness directly affects filtration efficiency and shedding rate
- Fiber penetration controls in-core failure potential

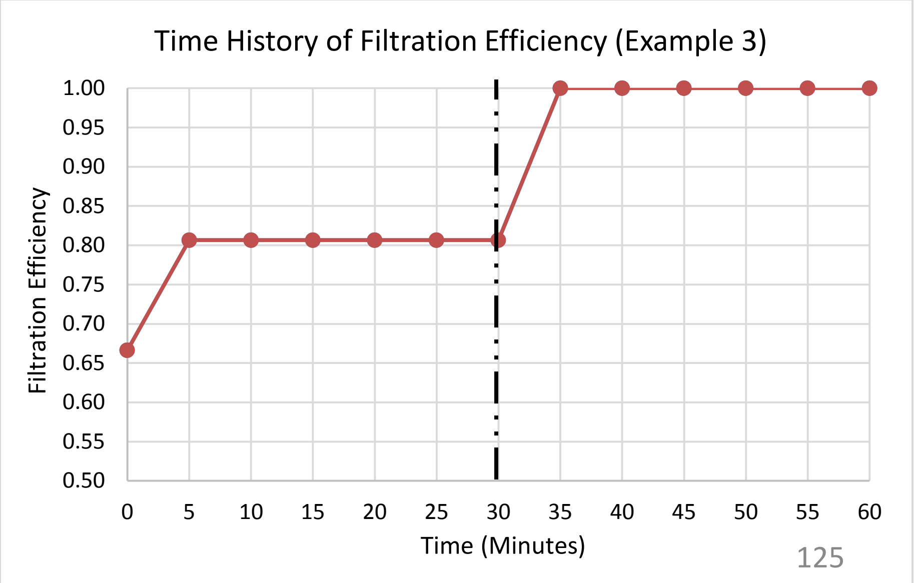
CASA Grande Examples

Results (Fiber Penetration and Boron Fiber Limit)

- Example 1 (Success)
- Example 2 (Sump Failure)
- Example 3 (In-Vessel Failure)
- Recirculation Time — · · — · · ·







CASA Grande Examples

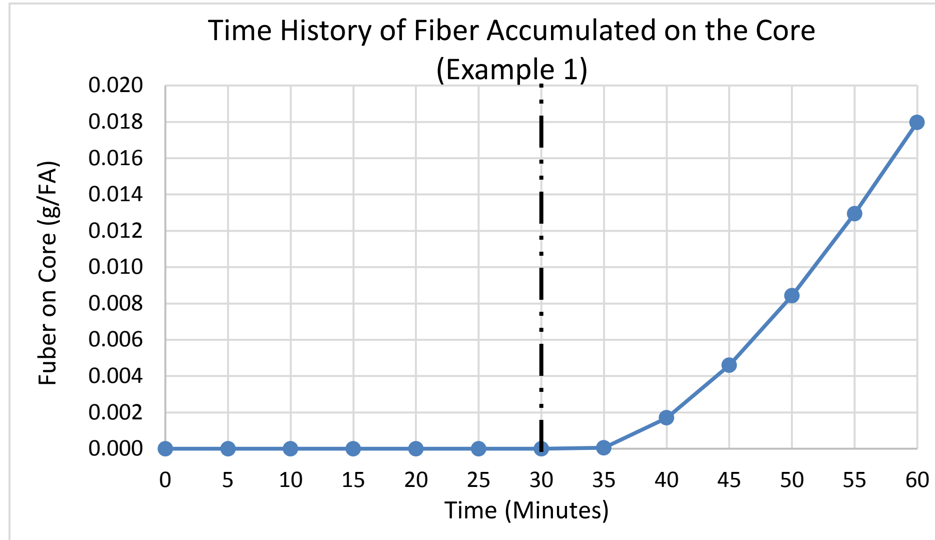
Results (Fiber Penetration and Boron Fiber Limit)

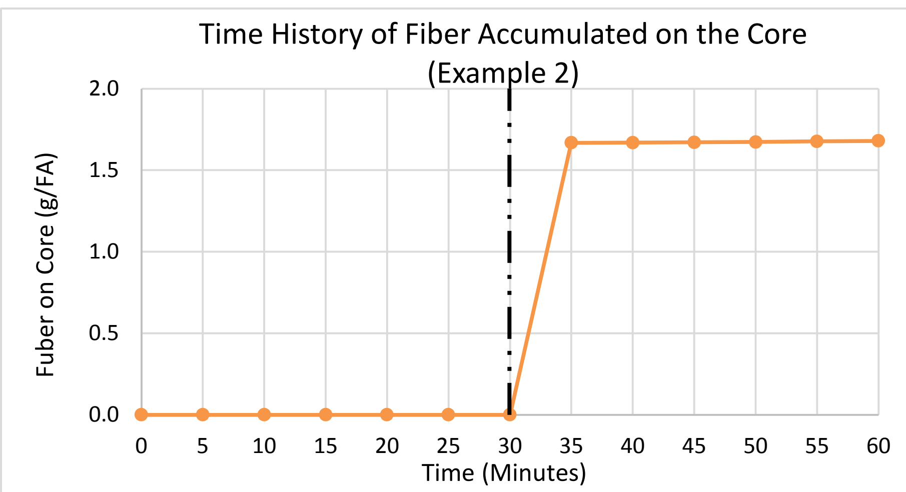
- The STP evaluation considered a user input core fiber limit of 7.5 g/FA
  - At each time step fiber deposit on the core is calculated
  - At each time step the cumulative amount of fiber deposit is compared with the Core Fiber Limit

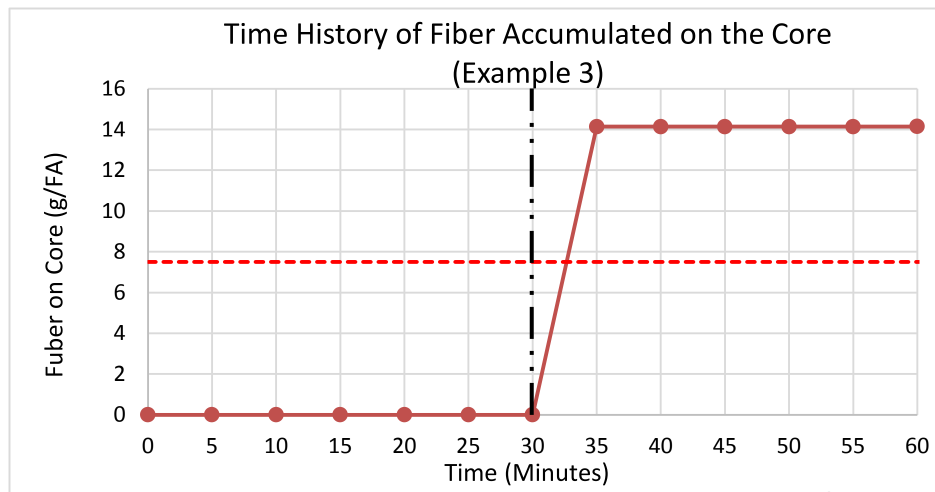
CASA Grande Examples

Results (Fiber Penetration and Fiber Limit)

- Example 1 (Success)
- Example 2 (Sump Failure)
- Example 3 (In-Vessel Failure)
- Recirculation Time — · · — · · ·







CASA Grande Examples

Results (Fiber Penetration and Boron Fiber Limit)

- Example 1 (Success)
- Example 2 (Sump Failure)
- Example 3 (In-Vessel Failure)