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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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THERMAL-HYDRAULIC PHENOMENA SUBCOMMITTEE

OPEN SESSION

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THURSDAY, APRIL 18, 2019

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2D10, 11545 Rockville Pike, at 8:30 a.m., Michael L. Corradini, Chairman, presiding.

COMMITTEE MEMBERS:

MICHAEL L. CORRADINI, Chairman

PETER RICCARDELLA, Vice Chairman

MATTHEW W. SUNSERI, Member-at-Large

RONALD G. BALLINGER, Member

WALTER L. KIRCHNER, Member

JOSE MARCH-LEUBA, Member

JOY L. REMPE, Member

ACRS CONSULTANT:

STEPHEN SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

WEIDONG WANG

ALSO PRESENT:

ALAN BILANIN, Consumer Dynamics, Inc.

VIC CUSUMANO, NRR

MIRELA GAVRILAS, NRR

PAUL KLEIN, NRR

STEVE SMITH, NRR

*Present via telephone

P R O C E E D I N G S

(8:28 a.m.)

CHAIRMAN CORRADINI: Okay, the meeting will come to order. This is a meeting of the Thermal-Hydraulic Subcommittee for the ACRS.

My name is Mike Corradini. I am Chairman of today's Subcommittee meeting. ACRS Members currently in attendance are Matt Sunseri, Walt Kirchner, Ron Ballinger, Joy Rempe, and we're expecting Jose March-Leuba.

Our consultant Steve Schultz is also with us today. Member Dennis Bley will be on the phone on the bridge line which we have a private line open for use. And Weidong Wang of the ACRS staff is the Designated Federal Official for this meeting.

Today's meeting, in today's meeting the Subcommittee will review a staff technical report entitled, Technical Evaluation of In-Vessel Closure Based on Low Safety Significance. The Subcommittee will hear presentations by and hold discussions with the NRC staff and other interested persons regarding this matter.

The Committee has received an email with a paper from a public member, Alan Bilanin, et al and they requested time to make an oral statement at the end of our public session which we will do so in today's meeting.

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

Attendance at these portions of the meeting that deals with such information will be limited to the NRC staff and those individuals and organizations who have entered into an appropriate confidentiality agreement with them.

So consequently, after we have our public session we will need to confirm we only have eligible observers and participants in the room for the closed portions of the meeting.

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

Let me just break from our normal thing and point out that this is an information meeting. We have a draft report that is in front of us which is being looked at by staff and reviewed and revised.

Therefore, there is no anticipation that we will write a letter from this meeting. Rather there will be a subsequent meeting after we see a revised version of the staff's report.

Rules of participation on today's meeting have been announced as part of the notice in the meeting previously published in the Federal Register. A transcript of the meeting is being kept and will be available as stated in the Federal Register notice.

Therefore, we request that participants in this meeting use the microphones located throughout the meeting room when addressing the Subcommittee. If the participants would first identify themselves with sufficient clarity and volume so they may be readily heard.

And just so we all check you have all your various appliances, things that beep and boop, et cetera, make sure they're all turned off so that they can do it to you silently then you can deal with it.

We will now proceed with the meeting. I'll start by calling on the NRR staff and Dr. Gavrilas will kick us off, Mirela.

DR. GAVRILAS: Good morning. I'm Mirela Gavrilas. I'm the director for safety systems in NRR. And I have a list of questions that the staff gave me and said talk about these by ways of introducing the topic to the Subcommittee.

So the first question they wanted me to address is why we did this. We did this because our relatively new office director came in with a fresh set of eyes.

And one of his principle objectives is to right-size the expenditure of resources in NRR and throughout the business line. So he looked at this and he said why don't we look at what's still needs to be done under GSI-191 given its safety significance.

So that was the incident. That was the driving force. The second is why this specific item was chosen. Frankly, because it's been around a long time and we feel that a lot has been done by industry and the staff has had ample opportunity to understand what's going on.

So it was definitely the right topic to choose for this right-sizing effort. The next question is why is this an adequate methodology? So under adequate methodology a methodology is adequate for its particular purpose.

So let me talk about the purpose of this report. This report assesses the safety significance of in-vessel effects. And its main purpose is one, to close out the generic issue and two, is to inform our compliance discussions.

I want to remind the Committee that we still have a generic letter out there that the staff is still trying to figure out what to do about. We're still evaluating if any adjustment of course is needed in that arena. And this report is also helping with that.

CHAIRMAN CORRADINI: Can I interrupt you?

DR. GAVRILAS: Absolutely.

CHAIRMAN CORRADINI: Just for clarification, so the generic letter we're speaking of is the --

DR. GAVRILAS: GL-2004-02.

CHAIRMAN CORRADINI: The 2004 letter. And the report will help inform that but is not intended to close that out?

DR. GAVRILAS: That's right. So the report is going to, there is one big issue in that report and generic letter which says are you in compliance.

And then there's an explicit tell me how bad in-vessel effects are. So both those are in the generic letter. So this report goes to address both those issues.

But again, the path for closure of that letter has not been discussed. We want to address the compliance next. So this is the first step. The next step is going to be compliance.

The third step is going to be what do we do about the generic letter. Did that answer your question?

CHAIRMAN CORRADINI: Yes.

DR. GAVRILAS: So we are here soliciting the Members feedback on the technical issues. And by way of admonition not every statement that the staff will make is going to have, is going to be equally defensible.

So some will be, will have better documentation, better technical basis for some points we make and some depth of the technical basis may be uneven throughout. So we think that is appropriate given the overall picture, the overall look at the issue and the conclusion that the staff made.

So we're looking forward to your feedback. Thank you.

CHAIRMAN CORRADINI: Okay. Thank you very much, Mirela. So we turn it to Steve.

MR. SMITH: Yes.

CHAIRMAN CORRADINI: Are you the man on the hot seat, so to speak?

MR. SMITH: I'm starting us off.

CHAIRMAN CORRADINI: Okay, all right. Steve, take it away.

MR. SMITH: Yes. I'm Steve Smith. I'm going to start off the presentation and this is on the safety significance of in-vessel downstream effects on long-term core cooling.

Our other presenters are going to be Paul Klein, Ashley Smith, Ben Parks, Steve Bajorek and Joe Staudenmeier. We've also had input from a lot of other staff at NRR and research and particularly DMLR, DSS and DRA and then research really did a lot of good TRACE work for us.

On the next slide, well I'm in control of the slides so I can flip. This just shows what we're going to be talking about today. I'm not going to spend a whole lot of time on the first few slides.

And so if people are unfamiliar or have questions please stop and we'll try to answer your questions as we're going through the first few slides. We're just going to talk about the background of the generic safety issue and the generic letter pretty quickly.

We'll talk about NRC and industry actions. We're going to talk about the approach of the technical evaluation report that we did to address in-vessel downstream effects.

And we do have a new acronym that I'll have to give Ben Parks credit for creating IVDEs because it's too hard to write in-vessel downstream effects all the time.

So before we move ahead we just want to say thank you to the ACRS for listening to us today and giving us some feedback. The paper we sent you, it was not finalized.

We've got feedback that it was confusing, it wasn't clear. So we're working on clarifying the paper and, you know, any feedback we get from you guys today we'll incorporate into the paper.

CHAIRMAN CORRADINI: And just so you guys were on the record to say this is that of course this is individual Member comments. Since we're not writing a letter report I won't confirm or deny the quality of the comments.

MR. SMITH: Okay. We'll consider the quality as we attempt to incorporate them. Today we're favoring the right side of the room. Tomorrow it might be the left. We're not sure.

So on the next slide, Slide 3 this is just a little bit of background. This issue has been around for a long time. As Mirela pointed out the

GSI-191 did not identify in-vessel effects.

And it also didn't identify chemical effects. Those were identified and included in Generic Letter 04-02.

So I'm going to move to the next slide because I think Mirela covered all of that. This is, Slide 4 is the licensee actions to address effects on long-term core cooling.

There is a list of things that were done here by all of the plants or a couple of them might have only been done by some of the plants. But all of the plants have taken significant steps to help deal with the debris issue in containment.

CHAIRMAN CORRADINI: And just to put it here just so, and there's, maybe you're going to say this, but there is a population of plants with what I'll term the bounding or conservative assumptions that one must make still may have challenges to get to the resolution state at this point. Is that a fair way of putting it?

MR. SMITH: Yes. We'll go into a little bit more details.

CHAIRMAN CORRADINI: Okay, thank you.

MR. SMITH: The next page we talk about sump strainer status. And we'll talk about it here because most plants already have acceptable strainer evaluations.

And then as you just talked about there are some plants that may not have a good strainer evaluation. So SECY-12-0093 allows plants to use risk-informed option or the deterministic options which most of the plants have used to come up with their evaluations.

STP, South Texas, that was the first plant that had a successful risk-informed LAR go through the staff. And they have closed the issue based on that LAR. So there's other plants that are moving along with that.

CHAIRMAN CORRADINI: There are, that was my question. So there are other plants that are following that way?

MR. SMITH: Right. We have two in house right now that we're working on. We have Vogtle and Calvert Cliffs. And there's a few other plants that are planning on coming in with a risk-informed evaluation. And --

CHAIRMAN CORRADINI: If I might just make sure I understand. So let's say we see the next version of this technical report which clarifies things and kind of evens out the analysis and the discussion, this would then be used in some way of evaluating pieces of these applications?

MR. SMITH: It would be used only for in-vessel. The strainer evaluation --

CHAIRMAN CORRADINI: That's what I should have said, okay.

MR. SMITH: -- is unaffected. So the last bullet here says we expect the strainer performance to be evaluated in the ways that are currently accepted. The in-vessel we're only looking at in-vessel.

CHAIRMAN CORRADINI: Okay, thank you. So just, not to bring up the South Texas, but my memory is that when we did the South Texas there were a number of conservative, I'll say bounding assumptions used in the in-vessel that might be relaxed based on analysis that evolve from the technical report?

MR. SMITH: That's correct.

CHAIRMAN CORRADINI: Okay, all right. Thank you.

MR. SMITH: Okay. So the next slide, Slide Number 6 it talks about what was done in the past WCAP-16793. That's a previously approved in-vessel evaluation method.

It established a 15 gram per fuel assembly fiber limit which was pretty much staff imposed by a condition limitation. Below 15 grams the testing showed that there wasn't significant head loss even when chemicals were included in the test.

So 19 units were able to close out using WCAP-16793 and the 15 gram limit. And we have completely closed the generic letter for those plants.

So those plants in STP that makes 21 units are completely closed out as far as the generic letter is concerned. The only thing that is not closed for all plants is boric acid precipitation which we will address in our TER in our discussions today at least.

MR. KLEIN: And it's probably worth mentioning that boric acid precipitation was not part of the generic letter of 2004-02.

CHAIRMAN CORRADINI: Right, that came up following.

MR. KLEIN: I think that issue was actually raised before that. But it's been carried for a long time.

CHAIRMAN CORRADINI: Okay, all right.

MR. KLEIN: What was new was that --

CHAIRMAN CORRADINI: I know there was testing that illuminated what were the contributors. But I couldn't remember if it was before or after.

MR. KLEIN: I think the new part of it was there was a question if a debris bed at the core inlet could lead to faster boron precipitation because you might not have exchange of the fluid between the lower plenum and inside the core.

MR. SMITH: And the other thing is the last bullet, STP as we talked about. They did a plant-specific thermal-hydraulic analysis which was relatively conservative to show that in-vessel effects wouldn't be an issue for them.

One of the things, on the next slide one of the things that you had asked for was to talk about RoverD a little bit. And since that was what, that's the methodology that the South Texas project used.

And I should define RoverD. It means risk over deterministic. I should have put that on the slide but I forgot. So since we just talked about STP this is a good place to bring this up.

They were -- there are some aspects of the TER that we're writing that are similar to RoverD. One of those is the TER accepts the most frequent smaller breaks because of low debris amounts. This is similar to what was done with RoverD.

There are some differences. We don't really use Reg Guide 1.174 as a methodology or a basis for our decision. We do use some of the ideas from

Reg. Guide 1.174. But we don't really follow all the guidance of that.

We don't use PRA at all in the TER. I mean, we use some frequency numbers out of NUREG-1829. But that's about as close as we get to that. And the PRA was used to some extent in STP evaluation.

So basically RoverD was a more specific, plant-specific analysis that was done and calculated plant-specific risk numbers and the TER is more general and draws conclusions about the fleet.

So the next page this talks about a WCAP that was written, WCAP-17788 that the staff was reviewing and working with the PWR Owners Group on. This WCAP was intended to allow higher debris limits based on plant-specific parameters.

It was also to address boric acid precipitation which was not addressed in 16793. And we would like to point out that this was a significant effort.

This WCAP came in, in six volumes, each volume addressed a different aspect of the issue. We had an overall. We had thermal-hydraulic analysis, chemical effects, cold leg break.

So there were several volumes and it was a lot of work for both the industry and the staff.

And there was a lot of good information that came out of that.

So we attempted to use that information to move ahead. And the next slide gives some information on the review status of the WCAP.

And it shows, I think the main thing to take away from this slide is that when we started work on the TER this is where we stood, the status in the middle column.

We had developed a large number of conditions and limitations based on the review. And it would have required significant plant evaluations and a lot of review from the staff to make sure that we agreed with the way that the issue was being closed.

So instead of moving forward with that we started working on the TER. So if you look in the third column I think the main thing that could be of interest is the second row down which is how we used the TH analysis even though we had some unresolved issues with it.

We still used the debris limits from the WCAP. We used it to demonstrate, to help us understand how the flows inside the reactor vessel go and also to demonstrate alternate flow path viability.

And alternate flow paths ended up being a defense in depth measure for us. We didn't count on them as the main way to cool the core. We assumed that the flow was still going to come in through the core inlet.

But the alternate flow path still provided viability, a viable flow path. All right, next, yes.

CHAIRMAN CORRADINI: So if you're going to do it later that's perfectly fine. I am very interested in the brine rod testing because it's been referenced in the memo or in the document a number of times about various things observed that you're, I'll use the word, taking credit for from the physical phenomena standpoint.

So that will be discussed later, I assume?

MR. SMITH: I will discuss it now because we don't really have specific discussions on it. I'll try to give a high level idea of what was done with that.

So the brine testing it was a program that was basically meant to show if you form a bed at the core inlet and you have a dense fluid which could, meant to represent concentrated boric acid in the core much denser than, you know, regular coolant what that would do to the debris bed.

So we didn't use any quantitative results from it. But qualitatively it showed that if you had a debris bed at the core inlet and had a dense fluid above the, in the core area and a less dense fluid in the lower plenum that you would get some exchange flow.

And actually in some cases it would disrupt the debris bed.

MEMBER KIRCHNER: So it wasn't a chemical effects test it was a fluid density test?

MR. SMITH: That's right.

MEMBER KIRCHNER: So we're really talking thermal-hydraulics, we're not talking chemistry?

MR. SMITH: Right.

MR. KLEIN: You know, I think the potassium bromide solution was just a convenient way to try and simulate the density that you get with concentrated boric acid.

CHAIRMAN CORRADINI: The reason I asked the question and I think we are going to have to eventually get, because there are a couple comments about inability to, now I can't find it, inability to actually totally close off the core.

And then there was a reference to the brine testing. So I guess I want to understand that connection. So maybe I'll wait because we'll see some TRACE calculations in the closed session, right so we will talk about that.

We can wait -- I'm not -- that was the one thing on your list here on the table. And I guess, well that was the main thing on your table that I wanted to bring up.

So I had questions that I think are related to calculations. So why don't we just wait.

MR. SMITH: Okay. And we may have to get you the brine test report so you could understand.

CHAIRMAN CORRADINI: That's fine. At least we can discuss it when the TRACE calculations are discussed.

MR. SMITH: Okay. And we may get the PWR Owners Group to come and discuss it if you have detailed questions because they're the experts. Okay, so this slide --

CHAIRMAN CORRADINI: I'm sorry. I found it finally. It's on Page 11.

MR. SMITH: Okay.

CHAIRMAN CORRADINI: There is a paragraph that talks about this test in relation to the inability to 100 percent block the core. So that's where I was kind of making the connection. So we'll wait.

MEMBER REMPE: So since we've interrupted you, is there something with respect to that table that you want to talk about here or later about uncertainties with respect to some of the results and impact?

MR. SMITH: As far as the thermal-hydraulic analysis?

MEMBER REMPE: I'm thinking more the chemical effects testing.

MR. SMITH: Paul discussed --

MR. KLEIN: We can discuss uncertainties when get to the chemical effects slide in that area.

MEMBER REMPE: Okay.

MR. KLEIN: That's one of the things that we had them look at. But I think in a more global picture some of the uncertainties with the thermal-hydraulic analysis are what caused us to maybe approach the overall logic in a different way instead of just assuming that the core inlet blocked and that alternate flow paths would provide cooling.

We thought with the uncertainty there it might be more appropriate to move that to a defense in depth mechanism even though we think it is a viable cooling path particularly as you go longer out in time before the core inlet could be blocked.

So we have a primary argument that it won't be blocked and then the alternate flow path part really becomes a defense in depth mechanism which we thought would allow us to have more uncertainty.

MEMBER KIRCHNER: Could you just clarify the very last, the bottom line? What do you mean by using TER not applied to cold leg break?

MR. SMITH: We didn't use --

MEMBER KIRCHNER: Because you examined cold leg breaks obviously in the TER.

MR. SMITH: We talk about that. But we really didn't use information from the WCAP in our analysis.

MEMBER KIRCHNER: Okay, thank you. That's what you mean but the TER itself is meant to be --

MR. SMITH: Right, it was --

MEMBER KIRCHNER: -- inclusive of all these phenomenon.

MR. SMITH: Yes, and the cold leg break volume, which is Volume 3 it was mostly talking about how to calculate how much debris arrives at the core for that situation. So we didn't really use that information.

All right. The next slide is just very

high level slide on where we stood with the TH analysis when we started working on the TER.

I'm not going to spend a lot of time here because we have several slides that talk about, you know, the TH analysis. So this talks about the in-vessel downstream effects safety significance approach.

As Mirela said, NRR's concept we're transforming to align our resource and industry's resource expenditures with the safety significance associated with various issues. So we took a look at this issue to determine what the safety significance was and safety significance is and determined how much effort we should put into it.

You know, should we continue with the WCAP review or should we try something that might be, take less resources from all parties. And this second bullet, it just lists the most significant technical information that we looked at when we were doing this evaluation.

Go to the next slide. So when we started on this task the Agency really didn't have a definition for what is low safety significance. So we started looking at existing guidance to come up with something we could use as a metric.

So we looked at Reg Guide 1.174 which is use of PRA in licensing basis changes. That's a paraphrasing of what the title is, it's long.

And then we also looked at NUREG/BR-0058 and that's regulatory analysis. And both of those things give us some ideas about, you know, what's acceptable as far as risk is concerned.

So looking at both of those an issue would be safety significant if you could reduce core damage frequency by more than ten to the minus five per year. Our evaluation shows that in-vessel downstream effects do not meet this threshold.

And in addition to that we believe that there is some significant defense in depth beyond, you, now even if we just consider what happens if the core becomes blocked. That's where we look at the ten to the minus five number.

And then if that happens there's still defense in depth.

CHAIRMAN CORRADINI: So, but let me ask the question about the third bullet. Since you said earlier you're not doing this as a risk calculation. So how do you determine a risk number?

MR. SMITH: Basically we look at -- we're using this as a metric. So basically it's just going to be based on a break frequency. And then we can also look at other things.

We can say, you know, we have conservatism here or we don't so we think that it's actually greater than the break frequency number, you know, or the risk is less than the break frequency number that we're going to calculate.

CHAIRMAN CORRADINI: So let me say it back to you so I don't misunderstand. So you're point is from a bounding standpoint the break frequency number is, and everything else being conservatively assumed is essentially the upper bound or the risk of the event.

MR. SMITH: Right. So if the break -- we're assuming if the break occurs you go to core damage. So it's very simple, like you said.

CHAIRMAN CORRADINI: And then you're evaluating what we'll call additional margins?

MR. SMITH: There's additional margins in that calculation. And then if the core was to block, you know, if you get this ten to the minus six or ten to the minus seven break to occur and it causes the core inlet to block you have defense in depth beyond that.

CHAIRMAN CORRADINI: Thank you.

MEMBER KIRCHNER: So what would be, so let's think about it outside of this specific application of IVDE because we're seeing as PRA is being used to inform both submittals from applicants as well as the staff's reviews basically you are saying here that the break frequency is less than that number that you have on the view graph and so you just screen out the, let me restate what I was trying to say.

We've seen examples of using that to just screen out even analyzing anything in that particular area. Just say it's not part of the design basis events.

MR. SMITH: So we're not saying that at this point.

MEMBER KIRCHNER: No, you're not because you're putting a lot of effort into this particular area.

MR. KLEIN: I think the TER specifically says it's, the evaluation is specific to in-vessel downstream effect and we're not intending to set a precedent for people to just use that blanket approach.

MR. SMITH: Yes, and so, you know, just saying you don't have to consider it, that's not what this is intended to do. That's the compliance work that's being done.

So that's when that will be decided. We don't really know. We've had a lot of discussions. We have some theories about what would be good ways to do this.

But I don't think ignoring the issue is on the table.

MEMBER KIRCHNER: Actually I agree with you. But I'm just suggesting that we've seen incidences where someone comes forward with a number much lower than that and therefore it's not even evaluated.

MR. KLEIN: I think we're very sensitive to that.

MEMBER KIRCHNER: Okay. Thanks.

CONSULTANT SCHULTZ: In that regard the third bullet can be misconstrued. I think that's one thing that Walter is getting at.

That is to say it can be considered a blanket statement that can be applied in many different areas. But when you explain what you are doing this only sets a starting point for further determinations where you're investigating the technical events which lead to a conclusion in consideration of much lower risk profiles.

MR. SMITH: Yes, I agree. And we don't want anyone to take the third bullet here and put it in the headline of a newspaper, you know. We've got to keep all this in context of what we're doing otherwise we're going to get in trouble, you know.

CHAIRMAN CORRADINI: But, that's fine. But I view this as a selective application trying to risk inform where you're using some sort of bounding analysis to at least see where you sit and then evaluate margin which I mean, from my perspective you're not looking for absolute assurance.

We're looking for reasonable assurance of safety. So it seems, personally it seems reasonable.

CONSULTANT SCHULTZ: In that regard it sets the stage for that type of an approach.

CHAIRMAN CORRADINI: Right, right.

CONSULTANT SCHULTZ: But taken out of context it can be misconstrued.

MR. SMITH: Yes. And I think part of -- this is a new idea for us. So I think it's important for the ACRS to think about this as well because I think this is kind of the way things are going now.

You know, this is what we're seeing is where looking for things that are low safety significance. We're going to try to define those, figure out what the safety significance is and if they don't appear to be safety significant we may treat them differently than we would have in the past.

So I think the Agency is kind of moving this direction. It may move back in a few years. I don't know how things are going to go. But it's a good thing to think about.

CHAIRMAN CORRADINI: Okay, thank you.

MR. SMITH: So this talks a little bit about the TER scope. And this is kind of what we were just talking about.

One of the hardest things we had to do while we were writing the TER is to try to divorce compliance from safety significance because we have not really thought that way in the past. It's a new way of thinking.

By considering only the safety significance we are leaving probably a more difficult task for the people who have to work on the compliance part of this. The second bullet we did use integrated decision making and this is what Mirela was talking about when she opened up for us.

Engineering judgment is used more here than probably what we're used to doing. The TER can provide a basis to close the GSI, GSI-191 if we understand the technical issues well enough we can close that.

But then to close the Generic Letter 2004-02 for each plant individually we can consider -- we may consider some of this information. You know, it kind of depends how the compliance discussions go.

All right. So Slide 14, this is going to take a little while. This is what you were -- I was going to talk through the event here. So if I leave anything out or I don't give enough details please stop me.

I don't have hot leg switch-over on here. I'll try to remember to hit that at the end because I do have a couple more slides for the cold leg break and hot leg break to talk about hot leg switch-over. But it might be good to talk about it here.

CHAIRMAN CORRADINI: That would be fine, thank you.

MR. SMITH: So this diagram is just sort of typical. It would look different for different plants. The heat exchanger could be on the other loop.

The safety injection system might be called something else. But it's kind of a good, it's a good diagram for us to use and it's good for pretty much all the plants.

The first thing that happens is you have, I'm trying to get my pointer. Here you have a LOCA that occurs here. Say a LOCA break occurs here.

And in the area of that break you damage materials within the zone of influence. Materials have different zones of influence. Stronger materials have smaller zones of influence. Weaker materials or less robust materials have larger zones of influence.

So materials in the zone of influence are damaged. Usually it's insulation and coatings that we're worried about. After that the RCS empties during blow down.

For large LOCAs the SITs are going to inject, safety injection tanks. And this helps reflood and quench the core. And it also adds volume to the sump because it's going to eventually spill out of the reactor.

So it adds inventory to the sump. After that the ECCS starts and injects. And the initial injection is from the RWST or there's other names for this, BWST or RWT.

And it injects and it supplies, if the containment spray system starts it supplies the containment spray and it supplies the ECCS or safety injection system. This takes a minimum of about 20 minutes.

Could be, usually it's going to be longer than that. Occasionally, I guess it's possible to be shorter.

CHAIRMAN CORRADINI: But it's designed dependent upon the size of all the systems, et cetera, et cetera, et cetera?

MR. SMITH: The size of the RWST has a big effect and how many pumps start. Like if you all your pumps running it's going to empty faster. If you have, you know, if you only have one train running it's going to take a lot longer time.

Break size can have a big effect. As soon as the break gets down below a specific size depending on what the capacity ECCS is it may limit the flow.

For the more likely smaller breaks it's going to take longer than 20 minutes because the breaks are going to be small.

CHAIRMAN CORRADINI: But that's what you guys use as a, I guess you would call it a switch-over point?

MR. SMITH: The switch-over point is 20 minutes. That's what is considered for the switch-over. And that's pretty, generally conservative I would say or representative of the earliest that we would switch over.

As that tank is emptying you have containment spray running or just the LOCA break. And that's going to wash materials down into the sump down here around the strainers.

The strainers aren't in service yet. But this blue arrow shows that the sump is filling up at this time.

Some debris is going to settle, and some will remain suspended and reach the strainer. And materials that are damaged during the break and other materials that are in containment are dissolving at this time.

You generally have a high, an acidic -- the pH is acidic. And then if you have -- it depends if you have sodium hydroxide. You have different pHs so you dissolve -- aluminum is the main thing we're worried about dissolving, and Paul is going to talk about that a little bit later.

The unqualified coatings begin degrading. And that's due to the harsh environment. They weren't damaged by the jet, but they're all over the containment. And they generally take hours to days to degrade and fail and wash down to the sump.

CHAIRMAN CORRADINI: So that comes to my next question which is at this point for your analysis you're assuming, I'm not sure if we can say the number, you're assuming hours or greater?

MR. SMITH: Right.

CHAIRMAN CORRADINI: For the precipitation to occur.

MR. KLEIN: And we'll address that specifically in the chemical effects part. But it would be hours. And for most plants greater than 24 hours.

CHAIRMAN CORRADINI: Okay.

MR. SMITH: So by the time this external water source is depleted the strainers are submerged and you switch from injection to recirculation. So that's the 20 minute time frame for the large break.

And this can be automatic or manual or a combination. It depends on the plant design. And the, you continue injecting to the cold leg which is, there we go, you continue injecting to the cold leg here, which is the same place that the injection was injecting.

I don't know if I mentioned that or not. But anyway, for the first part of the event you always inject to the cold leg. So the strainer is now in service. The green line coming from this tank is valved out.

This is valved in. So this is supplying both the safety injection and the containment spray if the containment spray is running.

So what happens at this point is you have fluid circulating through the system. It's coming -- it's going through the strainers. Anything that goes through the strainer and goes to the ECCS system has an opportunity to reach the core inlet.

And it's different for a cold leg break and a hot leg break and we'll talk about that a little bit later. But anything that goes through the containment spray system is going back to the sump strainer and it's, as the debris builds on the strainer it's more likely to get filtered out.

So the less percentage of flow that's going to the core the less debris you get there. And over time just the amount of debris goes down. So --

CHAIRMAN CORRADINI: But if I might again, you'll get this in, but the assumption, the bounding assumption that you're using is you don't take credit for it, for the fines?

MR. SMITH: All the fines are assumed to

transport to the strainer. Now some collect on the strainer and don't go through. But we take credit for filtering on the strainer.

CHAIRMAN CORRADINI: Okay. Then I've got to come back.

MR. SMITH: We'll talk about that a little bit later on.

CHAIRMAN CORRADINI: Okay, thank you.

MR. KLEIN: What's not credited is any fines that would get held up on gratings or that might have a chance to get hung up on debris interceptors or sometimes at the strainer you'll get a pile of debris at the inlet.

And we've seen that could trap fines. So no credit is given for any of those features.

MR. SMITH: Okay. And then basically the last thing that happens here is the sump, as the event goes on the sump begins cooling. This increases your NPSH margin.

But it also leads to potential for chemical precipitation and higher head loss across the strainer.

And then I'm going to say after a few hours usually between, I think it's between like six and 24 hours approximately maybe a little bit earlier than six the plant will go to hot leg switch-over which will inject water to a different point so it will bypass any debris bed that might have occurred at the inlet of the core.

CHAIRMAN CORRADINI: So that's what I guess I -- thank you for bringing up. So is that part of an emergency procedure so that is they have procedures that say at this point based on some monitoring of some parameter go to switch-over?

MR. SMITH: Yes. It's not based on a parameter. It's based on timing. It's calculated to prevent boric acid precipitation.

CHAIRMAN CORRADINI: So the intent is to go to switch-over before you expect precipitation?

MR. SMITH: That's correct.

MR. KLEIN: That's not the original intent of the procedure. The original intent was to prevent boric acid precipitation because you weren't sure if you had a hot leg or a cold leg break.

So the hot leg switch-over or equivalent was originally intended to prevent boric acid precipitation.

CHAIRMAN CORRADINI: In the system?

MR. KLEIN: In the system, in the reactor vessel for a cold leg break.

CHAIRMAN CORRADINI: Okay, fine.

MR. KLEIN: The advantage is that if precipitation, chemical precipitation occurs after the time a hot leg switch-over we would expect the debris bed to be disrupted before it precipitates. And we'll talk to that later in some slides.

CHAIRMAN CORRADINI: Okay, thank you.

MR. SMITH: Yes, I'm sorry. I thought you were asking about boric acid precipitation. There's two precipitations so we've got to be careful.

CHAIRMAN CORRADINI: It's within the core or within the system. I understand, thank you.

MR. SMITH: Okay. So the next slide, better use the buttons. Yes, we're supposed to close the meeting now because we could get into discussions about specific.

CHAIRMAN CORRADINI: We don't want to do something that's inappropriate.

MR. SMITH: I'm glad somebody saved me there, saved me from a faux pas. So that's the end. I guess of the non-proprietary, so if maybe this would be a good time for questions.

CHAIRMAN CORRADINI: I was going to say I want to go around to make sure the Members have a chance to answer questions in public session. If we don't have comments from the Members, we'll turn and ask for public comments.

Okay. So, Paula, can you make the magic occur. Okay, so first I know there is a public comment from someone in the room.

So, Mr. Bilanin, are you here? Just go to the mic and identify yourself.

MR. BILANIN: Can you hear me?

CHAIRMAN CORRADINI: Yes.

MR. BILANIN: My name is Alan Bilanin. I'm head of Continuum Dynamics Incorporated. In the late 90s we conducted the technical program that formed the basis of utility resolution guidance document for the boiling water reactors.

Our strainer designs are both in some PWRs and most BWRs as well. Recently we've been working with BWRs on a concept called good debris which has the potential for improving net positive suction head margins at the same time increasing the time between suppression pool cleaning.

While conducting those tests we've noticed that if you deployed good debris you can significantly reduce downstream effects.

My question has anyone considered other defense in depth strategies for resolving strainer downstream effects such as seeding the sump with these engineering materials that in PWRs will both enhance the NPSH margin and reduce the fiber bypass?

It would seem that the use of these materials might permit plants to show that the current emergency core cooling systems can meet the design basis accidents which they were originally, under which they were originally licensed.

CHAIRMAN CORRADINI: Thank you very much. And just so the Members are aware, the paper we received is by Mr. Bilanin, et al that discusses this that's being presented.

So we were given something we can read after the fact. So anything else from the audience in the room? So why don't we turn to the phone line. The phone line should be open and volume up.

Is anybody on the phone line to make a public comment? Could somebody at least identify that the public line is open so we know you're out there?

PARTICIPANT: Yes. The phone is open.

CHAIRMAN CORRADINI: Okay. Anybody on the line, go ahead I'm sorry, excuse me.

PARTICIPANT: Just confirming that the public line is open.

CHAIRMAN CORRADINI: Okay. Anybody who

would like to make a public comment? Okay, hearing none let's close the public line. And then I'm going to ask the staff to look in the room and politely ask those that are not bona fide to leave.

And we'll take a minute or two to reorganize ourselves and then we can get into closed session.

(Whereupon, the above-entitled matter went off the record at 9:14 a.m.)

Technical Evaluation of In-vessel Closure Based on Low Safety Significance for Generic Safety Issue - 191

ACRS Subcommittee Meeting

April 18, 2019

Presentation Outline

- Background - Generic Safety Issue (GSI) – 191, Generic Letter (GL) 2004-02
- Industry and NRC actions
- Approach to address in-vessel downstream effects (IVDEs)
- Staff technical evaluation (TER) of IVDEs

ECCS Debris Effects Background

- In the early 1990s, NRC identified that sump blockage due to loss-of-coolant accident (LOCA) generated debris could challenge emergency core cooling system (ECCS) and containment spray (CS)
- GSI-191 for PWRs issued in 1996 to address strainer performance
- GL 2004-02 requested plant-specific evaluation of debris to demonstrate compliance with 10 CFR 50.46

Licensee Actions to Address Debris Effects on LTCC

- Installed larger strainers
- Removed unnecessary debris sources
- Removed some problematic materials
- Implemented administrative controls
  - Control materials in containment
- Implemented procedural changes
- Improved chemical effects attributes

Sump Strainer Status

- Most plants have acceptable strainer evaluations
- Some plants are using risk-information to demonstrate adequate strainer function
- No change to methodology for demonstrating strainer performance

IVDE – WCAP-16793 Summary

- Industry program (WCAP-16793) for the evaluation of the effects of debris in the reactor vessel (RV) on long-term core cooling (LTCC)
  - Test program based on bounding assumptions that cover all plant designs
  - NRC SE approved fiber limit incapable of blocking flow
  - 19 PWR units used guidance to demonstrate in-vessel debris would not inhibit LTCC
  - 5 additional "low fiber" units meet WCAP-16793 limits
    - Awaiting higher limits for margin or risk-informed LAR
  - 21 of 65 units closed at this time
- STP used plant-specific thermal-hydraulic (TH) analysis and risk evaluations to address IVDEs

RoverD Applicability to TER

- Similar – some breaks are shown to be acceptable based on low debris amounts
- TER not using RG 1.174 guidance or criteria
- RoverD used staff approved deterministic thresholds combined with PRA to assess acceptability
- TER safety significance values are order of magnitude
- TER considered DID and SM similar to RoverD
- TER uses integrated decision making, more engineering judgement, because models for some aspects of IVDEs have not been developed

IVDE – WCAP-17788 Summary

- Plant-specific evaluations with event timing considerations
- Higher debris limits
- Address NRC staff and ACRS comments from WCAP-16793
- Effects of debris, boric acid precipitation (BAP)
- Performed fuel assembly (FA) testing, chemical effects testing, TH analysis

WCAP-17788 Review Status

Technical Area	Status	Use in TER
Overall Approach	Conditions & Limitations (C&Ls)	Assumptions Understanding methodology
TH Analysis	Unresolved Issues	Establish debris limits Demonstrate RV flows Demonstrate AFP viability
Chemical Effects Testing	Limited C&Ls	Precipitate timing evaluated against HLSO timing
FA Testing	Limited C&Ls	Establish debris limits
Brine/Heated Rod Testing	Reviewed as Supporting Information	Provide experimental evidence of phenomena
Cold-leg Break	C&Ls	Not applied

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WCAP-17788 – Staff TH Assessment

- Code models not previously reviewed for phenomena unique to post-LOCA long-term cooling with debris blockage
- Modeling inputs not bounding of all plants
- Code outputs exhibited anomalies and behavior that was not fully understood
- PWROG did not support further WCAP efforts

IVDE Safety Significance Approach

- NRR - align agency/industry resources in accordance with safety significance of issue
- Staff TER - evaluate the overall significance of IVDEs, considering:
  - WCAP-17788
  - Break frequency (NUREG-1829)
  - TRACE RES analysis
  - WCAP-16793-NP-A
  - Autoclave and historical chemical effects testing
  - Risk-informed analyses (STP and Vogtle)
  - Strainer testing

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Safety Significance Criteria Determination

- Derived from RG 1.174 and NUREG/BR-0058
- Both tie back to Commission's Quantitative Health Objectives
- An issue would be safety significant if resolution would reduce core damage frequency (CDF) by $\geq 1x10^{-5}$ per reactor year
- Staff evaluation shows that IVDEs do not meet this threshold
- Defense in depth (DID) is maintained assuming complete blockage of core inlet

Technical Evaluation (TER) Scope

- Evaluation of IVDE safety significance only
- Integrated decision-making:
  - Engineering judgment, qualitative, quantitative, and risk information used
- Not evaluating regulatory compliance
  - Separate staff effort on compliance
- TER provides basis to close GSI-191
- TER will be considered in closing GL 2004-02

Plant LOCA Response