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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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JOINT FUKUSHIMA AND RELIABILITY AND PRA SUBCOMMITTEE

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FRIDAY

AUGUST 22, 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., Stephen P. Schultz, Chairman, presiding.

COMMITTEE MEMBERS:

STEPHEN P. SCHULTZ, Subcommittee Chairman

RONALD G. BALLINGER, Member

DENNIS C. BLEY, Member

CHARLES H. BROWN, JR. Member

MICHAEL L. CORRADINI, Member

JOY L. REMPE, Member

PETER C. RICCARDELLA, Member

MICHAEL T. RYAN, Member

GORDON R. SKILLMAN, Member

JOHN W. STETKAR, Member

ACRS CONSULTANT:

WILLIAM J. SHACK

DESIGNATED FEDERAL OFFICIAL:

JOHN LAI

ALSO PRESENT:

EDWIN M. HACKETT, Executive Director, ACRS

PHILLIP AMWAY, Exelon

SUD BASU, RES

ERIC BOWMAN, NRR

Y. JAMES CHANG, RES

RICHARD CORREIA, RES

HOSSEIN ESMAILI, RES

JEFFERY GABOR, ERIN

STEVEN KRAFT, NEI

GREGORY KRUEGER, Exelon

ABY MOHSENI, NRR

SEAN PETERS, RES

MARTY STUTZKE, RES

AARON SZABO, NRR

DOUG TRUE, ERIN

RICHARD WACHOWIAK, EPRI

*Present via telephone

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

P R O C E E D I N G S

(8:30 a.m.)

CHAIRMAN SCHULTZ: This is a joint meeting of the Fukushima Subcommittee and the Reliability and PRA Subcommittee of the Advisory Committee on Reactor Safeguards. I am Stephen Schultz, the Chairman of the Fukushima Subcommittee.

ACRS Members in attendance today are Peter Riccardella, Dick Skillman, John Stetkar, Dennis Bley, Mike Ryan, Ron Ballinger, Charlie Brown, Joy Rempe and Mike Corradini. Bill Shack, former member of the ACRS and former Chairman, is in attendance as an ACRS consultant. John Lai of the ACRS staff is the designated federal official for this meeting.

In today's meeting the subcommittees are reviewing the generic topic of BWR Filtering Strategies Rulemaking. The work reported is directed toward improving severe accident response for BWRs with Mark I and II containment.

We'll begin today with a briefing on this rulemaking process and its status. We'll then hear detailed presentations by the NRC staff and industry representatives on preliminary technical evaluations begin performed to develop and analyze various options for these filtering strategies.

The staff and industry will also present preliminary analyses, approaches and results related to human reliability analysis of operator actions required for implementing containment venting strategies.

The majority of the meeting today will be open to public attendance. For the agenda items on operator actions and HRA application on containment later today, the presentations will be closed in order to discuss information that is proprietary and confidential, pursuant to the Sunshine Act 5, USC 552(b), Paragraph C4. Consequently, at that time we'll need to confirm that we have only eligible observers and participants in the room for these closed portions.

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

The rules for participation in today's meeting have been announced as part of the notice of the meeting, previously published in the Federal Register. A transcript of this meeting is being kept, and will be made available as stated in the Federal

Register notice.

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

We've received no written comments or requests for time to make oral statement from members of the public regarding today's meeting. We may have participants on the phone line this afternoon, this morning and this afternoon. We will be placing the incoming lines on mute until public comment period, which will occur near the end of the meeting.

For the convenience of the public, we will hold the public comment period before the closed session, which is scheduled to begin about 4:15 p.m. this afternoon. We'll now proceed with the meeting. I'd ask you all to put cell phones or other electronic devices that have a volume switch on mute.

The meeting again is an interim progress briefing. And we'll be discussing in the subcommittees subsequent actions at the end of today's meeting. Now, I'd like to call on Aby Mohseni, NRR, to lead us into these discussions with his opening remarks. Aby.

MR. MOHSENI: Thank you very much, Doctor Schultz. Good morning. I'm Aby Mohseni, Deputy Director for the Division of Honesty in Rulemaking for NRR. We appreciate the opportunity to address the committee today on the staff's activities with respect to the filtering strategies and severe accident management rulemaking for BWR Mark I and Mark II containers.

Recently the steering group for this particular rule agreed to require this rulemaking, Containment Protection and Release Reduction rulemaking, or CPRR. You will hear more on this change later. Staff is here to present on the analytical methodologies for CPRR.

The discussion today by the staff includes a discussion of the regulatory basis development and status by Aaron Szabo, next to me. And later on we'll hear from Eric Bowman from the Division of Japanese Lessons Learned, as well.

The probabilistic risk assessment by Marty Stutzke, the MELCOR analysis by Sud Basu and Hossein Esmaili, and the human reliability analysis by James Chang. The staff is not presenting any final calculations at this meeting. And any calculations that are presented are preliminary, and may change as part of the ongoing rulemaking process.

All of the information provided today, including the probabilistic risk assessment, the MELCOR analysis and the human reliability analysis, as well as the MACCS analysis. And the uncertainty sensitivity analysis will be used to inform the regulatory analysis and backfit that will support the draft regulatory basis document that will be public in the December 2014 time frame. This will also inform the decision on whether to proceed with rulemaking.

In the regulatory analysis for the CPRR rulemaking the staff will account for the effects of human actions on the overall risk by applying the appropriate sensitivities. We will still be evaluating how and to what extent the current HRA work will be used in the rulemaking. Thank you.

MR. SZABO: Thank you for meeting with us this morning. I'm Aaron Szabo in NRR. I am serving two roles in this project. I'm both the project manager, as well as the cost analyst who will be performing the regulatory analysis and the backfit analysis.

So, this morning to start off I want to go through a little bit of the history. I know many of you are familiar with it, the purpose of the rulemaking, the process and schedule, including, more important focusing mostly on the regulatory basis development, the alternatives that we're currently thinking about evaluating, what the staff's preliminary performance goal is, as well as what the current status of the rule is.

Just as a short history, the staff provided the Commission SECY-12-0157 that recommended an order to install severe accident capable vents with an external filter on all BWR Mark I and Mark II containments. We met with ACRS through the development of that. And had many discussions with the ACRS in relation to that SECY.

We received direction back from the Commission, and SRM to SECY-12-0157 to require, via an order, the installation of a severe accident capable vent. And directed the staff to perform a rulemaking looking at both an external filter as well as performance based alternatives.

And just to note, this will play later as we go through the development of the regulatory basis, as well as in relation to backfitting. Just as a little historical note, before core damage venting, which was EA-12-050, that was justified as adequate protection as an exception to a backfit analysis.

However, the post core damage venting was justified as a cost justified substantial safety enhancement in EA-13-109. So that was deemed to both be a substantial safety enhancement as well as to be cost beneficial.

MEMBER CORRADINI: Can you say that slower?

MR. SZABO: Sorry.

MEMBER CORRADINI: I got the first part.

MR. SZABO: Yes.

MEMBER CORRADINI: The second part I'm not sure, the nuances.

MR. SZABO: Yes. So, the first part of, in relation to the backfit rule and backfitting is, we see before we perform a backfit analysis, whether an exception applies. In the case of EA-12-050 an exception did apply. And that was adequate protection. So no backfit analysis was performed.

However, the order in 13-109 for the post core damage venting, the severe accident capable part, within the order it stated that it was actually considered to be a cost justified substantial safety enhancement, which meant that we went through the backfit analysis.

So, in that the Commission deemed that a severe accident capable event was both a substantial safety enhancement, and it was cost beneficial. However, it did not rise to the level of adequate protection.

CHAIRMAN SCHULTZ: And that was supported in the SECY document?

MR. SZABO: Yes. That was discussed in the SECY document. It was, sorry, it was Alternative 2 within Option 2, Alternative 2 within SECY-12-0157.

MEMBER CORRADINI: And then, I'm trying to ask the question. So that means the, let me make sure I've got this right. For an event, based on cost benefits, a severe accident capable event. But it was left unsaid about a filter?

MR. SZABO: Correct. They --

MEMBER CORRADINI: Okay. That's --

MR. SZABO: Yes, yes. They deferred trying to --

MEMBER CORRADINI: I'm just trying to --

MR. SZABO: Yes.

MEMBER CORRADINI: -- parse your words.

MR. SZABO: Yes. They moved the filter to rulemaking. And they said through an order they required severe accident capable vents. And then they said, we're deferring a determination on filters to the rulemaking.

MEMBER CORRADINI: Okay. Thank you.

MR. SZABO: Yes.

CHAIRMAN SCHULTZ: Thank you.

MR. SZABO: So, the purpose of the rule is to define performance based requirements to address the potential release of significant amounts of radioactive material from containment, following the dominant severe accident sequences at Boiling Water Reactors with Mark I and Mark II containment, and establish accepting criteria for confinement strategies.

We are looking at this rule as a performance based rule. I know Option 2, within SECY-12-0157 was, one could say more deterministic in relation to the look at filter. But we're kind of looking at both the filter as well as other filtering strategies in the scheme of a performance based requirement.

Original process and schedule. As Aby mentioned, the draft regulatory basis, the goal for that is around the December, the end of this year, early next year. That would be followed with a 45 day public comment period. We're not required to respond formally to any of the public comments. But we would use that to inform our final regulatory basis that's due September of next year.

That would be, that goes up to the Commission as an information paper. So we'd be stating how we're progressing to the proposed rule, if we decide to move forward with the rule at that time. The proposed rule is due a year later, September 2016. And based on a few, sorry.

Compliant with our cumulative effects regulation, we are also going to have draft regulatory guidance going out with the proposed rule. And that would go out for a standard comment period. We'd formally respond to that comment. And the final rule is due December 2017, with an implementation of the 2019-2022 timeframe.

To note, this is based on, these dates are different than what is stated in the SRM. This is based on two extension requests the staff has requested.

The first extension request was for nine months to the regulatory basis and proposed rule, leaving the final rule date the same. That was approved by the Commission.

The staff subsequently requested another nine months to the regulatory basis in the proposed rule. And we also requested nine months to the final rule. That has been approved up to the EDO level.

But we have not received any feedback from the Commission at this time. However, if they did decide to deny that extension that means we would have the final regulatory basis due in about January of next year.

MEMBER CORRADINI: January of '15?

MR. SZABO: Yes. So, I'm just letting everyone know that that is -- If they haven't voted and --

MEMBER CORRADINI: Okay, fine.

MR. SZABO: We would be likely to miss that date.

MEMBER CORRADINI: So, more another procedural question.

MR. SZABO: Sure.

MEMBER CORRADINI: But does this schedule, is this schedule consistent with the other aspects of post Fukushima activities, in terms of, there's a, you now have a word for it, but I'm going to get the word wrong. But I'll just say coordination of all these various activities?

MR. SZABO: So, these are all on different timeframes. So the bigger rule, I think it's MDMB now, the consolidated one that looks at Recommendation 8 --

MEMBER CORRADINI: Thank you.

MR. SZABO: -- and various other. That has, to my understanding, I believe the due date for the proposed rule is the end of this year. So this is lagging behind rather substantially, you can see our proposed rule isn't until September 2016.

MEMBER CORRADINI: The reason I'm asking the question is, I think I've asked it before in other meetings, but I'll just ask it again, since I haven't seen it. I'd like to see on one page how all this fits together. Because I'm confused. If I were the licensee I'd be really confused for licensees. So, is there some sort of plan that all this fits together?

MR. MOHSENI: There is a, obviously the relationship exists among these things. But, I'm very, they feed upon each other. And the strategy for achieving this thing also depends on the interactions with the industry and the connections that we have in terms of the information we need to proceed.

So, it makes it less ideal for having a total, you know, ideal interrelationship shown, and then having an implementation plan that actually benefits from that.

But it is as close as possible to the fact of where we are and how things can proceed. And this has been the case with, you know, rumors are generated, taken piecemeal.

MEMBER CORRADINI: Sure.

MR. MOHSENI: And unfortunately that doesn't help. That's the history and culture. And to stand alone they have to kind of pretty much get the focus on that. But in this scenario we have so many interdependencies going on all at the same time. It's one of the most difficult times that rulemaking in NRR has been experiencing in its lifetime. Eric, I should know, I mean, Eric Leads --

MEMBER CORRADINI: I mean, you were pointing out --

MR. MOHSENI: Yes. Eric Leads, in his

departure, before leaving NRC said the same thing, that this is one of the busiest times we've ever experienced in, at least in his lifetime. But this, and we're still going through that. Nothing looks easy on the staff's ability to --

MEMBER CORRADINI: I appreciate how --

MR. MOHSENI: So, we did give a one pager. But that one pager, when it comes to implementation, there may be changes that might occur along the way.

MEMBER CORRADINI: So, just so you understand what I'm asking. So, do the Commissioners understand how all this fits together?

MR. MOHSENI: I think to a great extent they realize that this is almost like fixing the airplane that's flying. And we are not necessarily having the luxury of actually having the resources to apply equally to all these various components.

And anything we touch, new items come out, out of it, that hadn't previously been anticipated. So, it is sausage in the making, in the background. So, if you wanted to see further, you know, we can also give you a little bit --

MEMBER CORRADINI: But --

MR. MOHSENI: -- more background. But

we'll give you the one pager that will give you the overview. And then the schedule. If you have questions on how does this inform another process that's going on.

MEMBER CORRADINI: Well, in theory we're not supposed to worry about this. But, so many things are going on at the same time. I mean, I kind of take your answer to be no, which is, it's not coordinated. But, at the very least I guess what worries me, and again, it's process. So officially we're not supposed to be concerned about process.

What worries me is, something will be asked of the licensees, and then it will be changed after something is physically done. And then changed again. So this chance of iteration, and I'll use the word needless iteration, concerns me. But I don't --

MEMBER BLEY: Well, the other side of that that we are concerned with is, sometimes when something's in place you don't change it again. And you live with something that's less than optimal.

MEMBER CORRADINI: Right.

MEMBER BLEY: And that can affect safety. So the idea of really mapping this out, even though it changes over time. I was just thinking, what if you tried to build a ship without a good plan for --

MEMBER CORRADINI: Yes, I mean --

MEMBER BLEY: -- putting it all together. It wouldn't work.

MEMBER CORRADINI: I guess that's another way of looking at it. I'm sure you have a plan. And I'm sure you have a Plan A, and then you've got a Plan B. But unless I am mistaken, I don't think we've seen even Plan A.

MEMBER REMPE: But I think what he said was he would give you the one pager. But it may change. And I think that you should take him up on that offer. Because we could see the interrelationships --

MR. MOHSENI: Thank you.

MEMBER REMPE: -- even though it would change. So, let's make that an action item and move on. What do you say?

CHAIRMAN SCHULTZ: I think so. And in that regard, to cover Dennis' comment, then we are interested in how the various implementation periods are coming together. And whether, and what plan is connected with implementation of rules as they move forward.

MR. MOHSENI: Very valid request, Dr.

Schultz. We'll get it to you.

MEMBER CORRADINI: Thank you.

MR. MOHSENI: And work on it, develop it. It will help all of us.

MEMBER CORRADINI: Dr. Rempe said it better than I.

MR. MOHSENI: Thank you.

MR. SZABO: I would like to clarify one thing though. It's not, the working group for these rulemakings, and the orders are not working in their own little tunnel vision. We are, there's a lot of cross working group members.

I mean, we have, I mean, between the large rule, this rulemaking and the order, there are people who are on all three, there are people on, I mean, it's, I go to a lot of the other rulemaking meetings to make sure we're staying informed.

So that if there are these type of things that could affect what we're doing in our rulemaking, that we're not implementing things that are counter to what we're trying to do in other areas.

MEMBER CORRADINI: Okay.

MR. SZABO: So we are --

MEMBER CORRADINI: Thank you.

MR. SZABO: So, I just wanted to clarify that.

MEMBER CORRADINI: Thank you.

MEMBER BROWN: Can I ask one other question relative to that --

MR. SZABO: Sure.

MEMBER BROWN: -- based on my confusion, which is still not clear? What are the plants required to do now? Just put in a reliable hardened vent capable for severe accident conditions? That's where one of the -- out of the SRM.

MR. SZABO: So, 13-109 superseded EA-12-050. So, right now the current requirements are, to my understanding, and we have that, the order people in here, if they want to say anything. For the pre core damage vent the only requirement is a wet well vent.

For the post core damage, a severe accident capable type vent, it's a two phased approach. Phase 1 is a wet well vent, which is currently, guidance has done in their implementation phase. And then there's a Phase 2, where there's two options.

A licensee can either show that, they can either decide to put in a severe accident capable dry well vent, or they can show that they do not have a need for that dry well vent. So that the, that they'll, the wet well will remain operational. So, it's a, mostly related to a water management kind of idea that they won't flood up the wet well. So that is the requirements right now.

MEMBER BROWN: And that --

MR. SZABO: Yes. So that --

MEMBER BROWN: And just my point being is that I walked away, and I wasn't quite sure what industry had to do now, and what stuff was on the table. And the way you just explained it didn't quite fit with this one page thing.

It's almost like you could have, here's what they're required to do. Here's another thing they're not required to do yet, because it's going to be evaluated.

But we've got to think about it, or whatever the heck it is. And there's something, I'm along with Mike. You can't come back after they've done one thing, and then say, rip it all out and put in something else, that's all.

MEMBER CORRADINI: Sure you can. They did it at TMI.

MEMBER BROWN: I know you can. But --

MEMBER CORRADINI: I'd rather not.

MEMBER BROWN: I know that, but --

MEMBER CORRADINI: That's why I asked the original question.

MEMBER BROWN: I agree. And I didn't get clarity out of the response. So, that's why I chimed in. I'm sorry about that.

MR. SZABO: You're right with the development. With the Commission putting this into a rulemaking phase there is the potential for there to be additional costs on the licensee, by them implementing the order as it currently is.

It might require additional modifications that could add costs that might not have been there had there been a filter requirement initially. There could have been some costs. I mean, there also is the potential for a licensee to set up their vent path.

And this is all based on whatever a licensee's regulatory risk they wish to take. They could theoretically set up a vent path that is, if we go to the filter idea it would help decrease costs.

Or they could, once again, just have the vent path that they believe is best, that would not accommodate a filter. And then if a filter is required, it would require modifications that would increase the costs.

MR. MOHSENI: So, as you can see, you're right, you know, there's a, this is not easy to follow. That's why I think the question was posed, how do these all come together? And there is no easy answer to that because of the developments with the stakeholders and us.

And every time we touch something it branches out into two or three other pieces. But then if it's a policy issue the Commission has to weigh in. And every time the Commission has to weigh in, it has some consequences one way or the other, generates a little bit more discussion, and more explanation of why things are the way they are, and why should you do anything less or more.

So, this is the process of rulemaking. It's very intensive. It's not easy coordination, not only internally to NRC, but externally. And various stages were actually opened up to public scrutiny. And then through that scrutiny you even get more complications. Valid. All of them valid. No one is saying life is easy.

And then in it you have the cost benefit analysis, which itself was the topic last week, of how difficult that becomes when you do qualitative assessment of certain aspects of certain outcomes. And yes, it is complex, it is very difficult. And you can only oversimplify it so much without losing the value of what it really is intended to achieve.

And that incremental benefit that we're after, and actually whether or not you add filters or not, requires all this analysis before you can get to that point of saying yea or nay. At the end of the day it's a complex scenario. And we are doing our best to give you the big picture, and then focus on the small components of that.

CHAIRMAN SCHULTZ: The one area that I caught that would be helpful to focus on, related to again Dennis' comments and Mike's as well, and Charlie's, was that originally the evaluation associated with the dry well vent was somewhat aligned with the previous schedule associated with the rulemaking, in that the licensees would be working through that process in a schedule that at least met up with the evaluations here.

Now, some of the evaluations here are

moving down the road. And yet, the schedule for the dry well vent decision making has not changed. So that area of scheduling and decision making ought to be investigated, given these changes.

MR. MOHSENI: Yes. And I think later on when you hear from the industry, I don't know if this message -- We heard this message yesterday. And that was a major issue.

CHAIRMAN SCHULTZ: And we may hear it today.

MR. MOHSENI: Yes.

CHAIRMAN SCHULTZ: Thank you.

MR. SZABO: Moving on to the regulatory basis development. This is trying to set a process for how the draft regulatory basis is going to come, be developed, or is being developed right now.

So, one of the lessons learned from SECY-12-0157 was that the first thing we want to do to save time and money in relation to MELCOR runs is to first establish what the event trees are. So, the event trees include a core damage frequency event tree and an accident progression event tree. And split fractions with all those.

And there are quite a few number of actual end states you end in. And that's based of course, the fractions are based on the probabilistic risk assessment and the human factors, and a human reliability analysis. Initially, at least right now, Marty has put in just screening values for the HRA.

As Aby mentioned, the level of detail that we will end up using within this regulatory basis and rulemaking is still under consideration internally. From those event trees establish what the dominant sequences were.

We then ran a MELCOR progression. MELCOR guys ran the dominant sequences based on plant parameters, mitigating features, failure states, and release pathways and sensitivities. And they'll discuss that later this morning.

That information is then fed into the MACCS, the offset consequence model, which then, based on atmospheric transport dispersion, protective action to the exposure pathways, health effects, offsite costs, and land contamination. And then there's a number of sensitivities that are going to be performed for that.

All that information then gets thrown back into the probabilistic risk assessment to give us probability weighted consequences per reactor year. That information is then fed to me. And I will develop the regulatory analysis, and if necessary, the backfit analysis, which will incorporate the number of units affected, the average years of operation, the dollar per person rem, the cost of implementation.

We received information from industry that's going to be considered in relation to the costs of implementation. A benefit cost analysis will be performed, at least for the regulatory analysis, if not also for the backfit analysis.

And then we'll of course also consider anything that we were not able to quantify as a qualitative consideration within the discussion of the regulatory analysis and the backfit analysis.

Included in that will also be a technical evaluation, which includes the performance goals objectives and criteria, the technical feasibility, and validation and testing of the alternatives. And so that will all feed into the regulatory basis document. And then that will, of course, go out for comment.

But the point here is, there's a lot of assumptions and steps that -- And these are running somewhat concurrently, but are, do require this path that's established. And that is kind of our path forward for the basis of development.

So moving on to the performance goal. This is a preliminary staff recommendation for the performance goal. We had some discussions at public meetings about a year ago. We realized it was more prudent to go through some more of the technical analysis before we really started thinking about what appropriate performance goals and criteria would be.

This is what we presented yesterday at our public meeting. And we are, this does not incorporate any feedback we received from the public at this point.

MEMBER CORRADINI: What sort of feedback did you get on this goal?

MR. SZABO: The initial feedback we got was just on the term minimizing, just defining that. And that's really what the performance criteria will do. Currently we're looking at a number of performance criteria.

I didn't want to present them here, because I think it's a little bit still too preliminary. We're still developing what they each mean, and how to meet success. Some of them, for example, would be, well there's two direct, two recommended within the SRM that we are considering.

One is a decontamination factor. So, for instance, minimizing could mean a decontamination factor of a certain amount. One of the things we want to talk about and discuss more is, what would we determine as a success of minimizing. That would help define minimizing.

The other one recommended in the rulemaking is equipment availability, similar to 50.54(hh)(2), which would be, minimizing would theoretically, the success of minimizing would mean that you have the equipment available.

Industry has recommended two criteria, one being a margin to the qualitative health, quantitative health objectives, and the other one being conditional containment failure probability. So there could be a, as long as you can keep the conditional containment failure probability, you know, at a certain level or below that would be considered minimizing, or success of the performance criteria.

The idea that I have, at least right now, at least for the reg basis, not necessarily picking a performance criteria that we're going to use, but at least have a thorough discussion of the performance criteria, what success would mean, and more of the feasibility of whether the alternatives can meet that success. And that's going to be an ongoing discussion that we're having.

MEMBER BROWN: How can they do their preliminary evaluation of the options you talked about earlier if they have, if they don't know what the downstream criteria are going to be? Whether that be contamination factor or one of the other ones, the other one you mentioned. How do they --

MR. SZABO: This was merely for the draft reg guide from --

MEMBER BROWN: I understand that. But they're already doing something, correct?

MR. SZABO: Yes. So, there's going to be two evaluations essentially, within the draft regulatory basis. One is going to be merely a feasibility of can they, can this meet the criteria?

The second is going to be, is the actual alternative cost beneficial? Until we do really the cost benefit analysis we don't know where the alternatives will fall out, such that you may have an alternative that's feasible that's not, you know, feasibly meets the success criteria that we think.

However, it's not cost beneficial. You might have something that's cost beneficial that does not, could not meet that success criteria. And that's kind of the level that I think is appropriate at this point, understanding we will have to refine it, especially as we get to the proposed rule stage. I mean, a reg guide can't be -

MEMBER BROWN: Yes. I understand that. My point is they're doing something now. And they're doing stuff with some goal in mind, I guess to meet some perceived downstream requirement. Am I off base as to that part?

MR. SZABO: No. You're correct.

MEMBER BROWN: And yet, it has not been defined yet. They've got to envision this potential acceptance criteria, whatever you want to call it, now, if they're going through that. And then, so they could be taking actions, they could do their design work.

And now, all of a sudden you come along and say, well, gee, we've determined that due to this contamination factor, or there's this other, whatever the other criteria was you mentioned, a new thing. And you all don't need that. And they've already started.

It's almost like putting the cart before the horse is you don't know what goal you're trying to achieve at the end point, and having anybody do anything in advance.

MR. SZABO: So, right, and industry can speak to this better than I. So, I will just speak is what I believe they're doing. So, for instance, when you're talking about design and implementation for EA-13-109, this re-arcing cable vent, the Phase 2, for instance.

One of the recommended ways to meet the Phase 2 is to have a water addition requirement, because it will help keep down the, some of the temperatures, whether you have a dry well vent, or you can show that you don't need a dry well vent. That design is based on them complying with that order, and not necessarily --

It may end up that they meet this rule as well by having water addition. But that is not the, to my understanding, the intention of that right now. The purpose of that is to, the water addition is to meet that order. It might have a secondary benefit that it also happens to meet this rulemaking.

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It may come out that they add water addition in this rulemaking, as I've said, you need water addition as well as an external filter. And that's my understanding of what their design ideas right now, based on what, complying with the order, and not necessarily potential complying with this rule, yes.

MR. MOHSENI: If you stand back and look at the big picture, you actually would be right. You know, they got orders. And they're interpreting that order and doing something. We, in parallel, are developing a rule.

Whether this rule actually materializes or not depends on the reg analysis. And this creates uncertainty. And you will probably hear from the industries, potentially a disincentive for them to interpret the orders in a more comprehensive way, anticipating that a new rule is coming.

They may not be sure from the cost assessment, you know, that this is a good investment for them to interpret their need for water management to be added to it, which the order did not include. But the interpretation is out there to actually interpret water addition as part of the strategy they want to implement. You will hear that. And it's a valid concern.

The sequence of events are such that the uncertainty is out there. And this rule proposal, regulatory analysis that we're doing, we meet with the industry in public, and we hear their concerns. And they're justified in the sense that the uncertainties do not help.

The process of going to the Commission, you know, we have an SRM. We follow the SRM. And then, of course, even if the staff proposes a path forward in the rulemaking process, it still depends on the Commissioner's decision ultimately to agree that no rule is needed, no additional work is needed. Or, if a rule is needed, what form or shape. So that uncertainty is inherently there that you're talking about, yes.

MEMBER CORRADINI: So, let me just ask, I mean, this is kind of a part of the big picture that I was asking about. So, to determine what minimizing means has in itself some sort of time in your plan where it's going to be decided upon, at least proposed. When is that?

MR. SZABO: At the, once again, this is my opinion. We might get direction that changes this. But this is, it my opinion the idea is to not make a -- Well, we wouldn't have a decision at eventually the draft reg for basis. You'll have, be requesting comments on that.

But potentially at the final regulatory basis stage is where I would see that we would have that determined. Because it has to feed into what the reg guide is going to end up saying. And the reg guide would need to be developed after the final reg --

MEMBER BLEY: But you have a proposal of that in the --

MEMBER CORRADINI: Yes. That's what I wanted to add. So are you, so, I'm just looking at your thinking. I'm just trying to understand your thinking process. The thinking process is, sometime by the end of this calendar year you'll have a surrogate definition of what minimizing is to test out --

CHAIRMAN SCHULTZ: You said that you --

MEMBER CORRADINI: -- actions.

CHAIRMAN SCHULTZ: You said you might only present it conceptually in the draft. And then finalize it in the next year, or the next nine months, with interaction with public. The question here is, aren't you going to propose something definitive, as a straw man, in the draft?

MR. SZABO: It might end up that way.

CHAIRMAN SCHULTZ: You don't know at this point?

MR. SZABO: Because we have to do our full analysis for it, to see what the feasibility is.

CHAIRMAN SCHULTZ: Okay.

MR. SZABO: All the alternatives. I mean, we got to, we can't pick a, necessarily a -- And we did need more information on, and more discussion on what each criteria is, before we really go through a we're definitely going to pick this and this success criteria. Because there's no point in picking a performance criteria without also having a success criteria with it.

So, there is the possibility that, I'm saying it could be that we have identified them all, and really done a feasibility look at, for instance, if we're looking at the contamination factor or similar alternatives, the decontamination factor that we pick around, of course, it's not being a strict bright line threshold. It would probably be more of a general idea.

It's like, okay, well, some of these alternatives can feasibly meet this, some of these alternatives cannot. Or maybe all of them can meet it. Or maybe none of them could meet it. We don't want to necessarily be picking something that doesn't really make sense, until we finish up the analysis.

CHAIRMAN SCHULTZ: All right. So, if you don't select it, are you going to send, are you doing to describe it as best you can, the process in which you expect the discussions to go?

MR. SZABO: Yes. So, the idea that I have right now is to have a thorough discussion of each criteria. And what we believe the success would be, success criteria would be under that performance criteria. And then, what of all the alternatives could meet this, this success criteria, and which ones could not.

And then we're separately also doing a cost benefit analysis of all of the alternatives. Because they're really two separate ideas. What is the, is it -- And that's why I didn't necessarily want to --

My thought right now is, I don't, we need to at least finish the analysis to see what the feasibility is before we really --

I didn't want us to say, we're definitely going to have something in the draft stage, because we might not. We might just say, hey, feasibly these alternatives meet these criteria. Public, we're looking for your input as to what kind of performance criteria makes sense.

Separately from that, by the way, we did a cost benefit analysis of the alternatives. And these alternatives are cost beneficial. So, and that's kind of at least where I, my initial though is, where we'll end up.

We might be further along than we end up in a more definitive place. I just don't know right now. I wanted to give the, I didn't want to say we're definitely going to have something, and you guys end up seeing something, where we have not necessarily picked something.

MEMBER BLEY: Can I back you up --

MR. SZABO: Sure.

MEMBER BLEY: -- to your last slide? I'd like to try to understand this --

MR. SZABO: Yes.

MEMBER BLEY: -- a little better. I'm not going on here to get to regulatory basis by December of this year, which means you've got to have the draft in house I suspect by no later than late October if you're going to get something out the door by the end of the year.

Can you just highlight a little bit through the steps of the analysis where we are? And NRC's doing all this analysis. But you're discussing those with the industry?

MR. SZABO: Yes.

MEMBER BLEY: Or is there some industry participation?

MEMBER CORRADINI: I'm sure they're doing almost a parallel set of calculations.

MEMBER BLEY: Well right. But I'm wondering, are they doing a parallel set? Or are you somehow working together? Or, how is this going forward?

MR. SZABO: So, there's been 12 public meetings, I think, thus far since the middle of last year. So, about once a month. There was a little bit of a, we took some time off, just because we were running

MELCOR, and they were running analyses earlier this year. So there was really no point in us meeting.

But, no, we've had thorough discussions with industry, setting our assumptions. We had a meeting last December, when it was really, the idea was to finalize all the assumptions for the MELCOR, and with their MAAP analysis. And we've, of course, been having more meetings presenting preliminary results on the PRA, and the MELCOR.

Internally we've been moving through the process. Although it's in aligned, a lot of the stuff is running concurrently. For instance, I'm building a lot of the regulatory analysis right now, the parts that, and just waiting for the input. And, as well as the event trees are pretty much -- As long as we've got to the point that we got, we can establish what the dominance sequences are.

We put that before the public. Industry weighed in. Once we kind of established those we could run the MELCOR. And then once MELCOR, each MELCOR run is finished, then we can start running through the MACCS. So it's kind of in parallel.

MEMBER BLEY: Well, since you've started the regulatory analysis a little bit, have you put together an argument why doing this for one plant, and for one, essentially initiating event scenario, in any case, is giving you an adequate basis to cover the range of things that could be happening, that might challenge this filter in various ways, including human interaction? I guess that's enough for now.

MR. SZABO: So, understanding that we are going with the basis of what cost the ELAP, the purpose of the event trees, and --

MEMBER BLEY: But have you got an argument about why nothing is, where that's good enough?

MR. SZABO: Yes. I mean, you get into this. I personally believe that the quantification that we're doing right now is enough. You, of course, can always do more.

I mean, we started, I would say we're pushing the limits as to our science, and what we can do. I mean, we have our guys chugging through quite a few different scenarios. Understanding that you have this base assumption as to what you're going in with.

The qualitative discussion will, of course, as well as uncertainties within the PRA, try and capture those inherent modeling uncertainties, if you will, about what it cannot capture.

You know, we're a risk informed agency, not a risk based agency. We, of course, understand that this, it's not that the PRA will, or the MELCOR or the MACCS is going to capture everything. The idea is that it provides enough information for us to help inform the decision makers. And of course, to put everything in context that it is appropriate.

MEMBER BLEY: But, you're really going all the way out to health effects, Level 3 kind of things for the scenario you're looking at. Given that, I'm a little, I'm wondering what kind of science would tell us, you know, using a DF as a deciding factor would be a reasonable thing to do?

I know you're going to have to get analysis done, and you're going to do it. But it seems to me, since you're all the way out to a Level 3, and you're looking at health effects on, and interaction with the population, DF is just part of the problem. It's hard to imagine that would be the answer.

MR. SZABO: That is merely one of the criteria we're evaluating. It's not necessarily the one that we would choose, or the one that, if we chose one, or the one we might end up using. That's why we're internally discussing this performance criteria right now. There is a lot of discussion on what should we be evaluating, what should we be using, to ensure we're doing what makes sense.

MEMBER BLEY: We're going to see some more details. But just one last question on this. And then I'll be quiet and listen to what you guys are going to tell us for a while. I hope in what you do in, that got to this analysis, that it will include looking at the filter, that you're looking at --

A filter says I've got a DF of 100. But it might not be a DF of 100 against everything under all possible conditions. And I hope you're looking at those ranges of things, and the experiments that I set up, such that there's a real look at the uncertainty associated with that performance. Is that true?

MR. SZABO: There will be a discussion of that. Of course --

MEMBER BLEY: Are putting in a DF and applying it across the board, and assuming that it works?

MR. SZABO: Well there's, within the event tree you'll see where their failure mode of, you know, bypass of the filter, when the filter is --

MEMBER BLEY: And now --

MR. SZABO: In relation to the performance of it, there will of course be a discussion of it, as well as the validation and testing of any filter use. What we might, at least for at this stage, in this specifically as well, for at least in the cost benefit side, we can take a more, we can look at a more conservative number first.

And say, let's assume, best case scenario, it does work all the time. What does that actually get us? Is that close to being cost beneficial? Is it actually, basically the screen, assuming that at first?

And then, with the discussion of course, the discussion of the uncertainties and performance would always be included. It's just whether we would be necessarily going and mapping even more in an event tree, as to what that failure probability is.

MEMBER BLEY: Well, I can see what -- I just hate to see all this massive amount of work if we're not applying a real good bringing of all the knowledge available as to how that filter's going to work.

MEMBER STETKAR: Let me just, you know,

I'm hoping that sometime before midnight we'll get to some of the details. And I was going to bring this up then, because it's an appropriate point.

It's nice to hear you folks glibly talk about we've treated the uncertainties and the PRA model. The fact of the matter is, you've not. No uncertainties have been quantified in any of the PRA models. And that's just a statement of fact.

So, whatever numbers you have right now do not include any treatment of uncertainty. So, if you think they've been treated, you need to go ask the PRA people. Because they're either not telling the truth, or you're just simply stating things here for the public record that aren't true. They aren't true. They have not been quantified in the PRA models, at this point.

MR. SZABO: That was what, in that context. I

(Simultaneous speaking)

MEMBER STETKAR: -- on the record the context --

MR. SZABO: Sorry, you're --

MEMBER STETKAR: -- is stated correctly.

MR. SZABO: Yes, at this point.

MEMBER STETKAR: That have not even been examined. There are not even uncertainty distributions available for parameters other than seismic hazards and seismic fragilities, or anything else. So I can't even figure out what they might be that I might be able to treat them as models. Because they're not addressed at this time.

MR. SZABO: Yes.

CHAIRMAN SCHULTZ: The other comment, since we're on this figure appearing, is that the technical evaluation box, which is off to the side and at the end. It would appear, at least diagrammatically, is obviously very important.

MR. SZABO: Yes.

CHAIRMAN SCHULTZ: And based on what has been provided so far in terms of information, the integration of those three bullets, the evaluation of those three bullets, validation testing, technical feasibility, performance goals and objectives, in fact does seem off to the side.

And they need to be integrated into the whole picture. It's not just a piece that comes in together at the end in evaluation and discussion. It needs to be integrated through the whole evaluation process in some fashion.

But at least, at least with solid engineering judgment based on those analyses that have been done. So, just a caution about how that needs to brought forward in order to accomplish a robust rulemaking and decision making.

MR. SZABO: So, going to the alternatives. We're looking at, this is a higher level. There's a significant number of sub cells alternatives in here that I can, I'll touch on very lightly. But the idea was, and this is where we get to the kind of changing of the name.

We had a list, a very long list of just numbered alternatives. And we realized that for the public, as well as for us, it was getting a little confusing, especially with our discussions with industry. And so, there was this idea that we put forward to try and move the alternatives into relation to kind of failure mode, looking at it based on failure mode.

So the first is just inherently always our no action/status quo. The second is overpressurization measures. So this would merely be codifying EA-13-106. In relation to the cost benefit, essentially all the costs and all the benefits are already sunk, since they're already implementing this

This is just whether, we'd be evaluating whether it's worthwhile to codify in this rulemaking. Because there would be some administrative expenses to it. So that wouldn't, that alternative we'll be looking at.

The third one is this Containment Failure Prevention Measure. And there is some release reduction you will get from water addition. But it's really more of what we're calling, right now at least, the Containment Failure Prevention measure. And it's looking at water addition to kind of prevent liner melt through.

So, the first analysis we would do is, do you need, is it worthwhile to look at, to do this at all? And then if so, we would then, we are then looking at water addition via the reactor pressure vessel, and water addition via the dry well to see that, is there a preference to either one, or one that we would require.

If that is cost beneficial we would then look at Option 4, which would be a release reduction and Containment Failure Prevention measure. So, the first one is a filtration strategy. So that's looking at, the various sub-alternatives for that would be looking at just water addition by itself.

So, we'd be saying, what type of release reduction are we getting from water addition? There would be no additional cost from what you'd have in alternative 3.

Another filtration strategy sub-alternative would be water management. We may get some additional costs from that. And of course, the water addition, the thing that starts to become very tricky is, you know, as I was mentioning before.

Phase 2 of the order, what industry is saying right now for compliance of the order, or what they've put forward right now is a water addition, no dry well vent, sever action capable dry well vent, water addition with a severe action capable dry well vent, and just a dry well vent without water addition. Those are the three ways to meet Phase 2 of the order.

So, if the licensee added water, had water addition to comply with the order, we kind of are back into what I was talking about with codifying the water, where you have a lot your benefits in your cost sum. However, and that would be true as well for the filtration strategies.

If they don't have, if they, to comply with the order they're saying, we are going to show that we can manage our water so we don't need a severe action capable dry well vent, well, they would, theoretically at least, if there is any equipment modification or removements they would need to make that they would do that for the order, to comply with that phasing order, so that cost would not be there within this rulemaking, as well as -- Well, that would just be a cost.

We are then looking at various ways for a small filter, and a large filter, with various ways of venting, whether wet well first, pre core damage, and then dry well first post manual dry well first, post core damage. We're looking at manual wet well first. Pre core damage, passive dry well vent, post core damage.

And we're looking basically at all the permutations of that, that just have a lot of sub-alternatives in them, and makes this very much more overwhelming than it already is. So, it's going to be, well it is right now a big effort in relation to trying to map.

And this gets to the mapping of the relation between the order and the rulemaking, and the assumptions we make in, for the cost benefit analyses. So, a lot, for the water addition, for example, I will be making an assumption of what I believe the status quo currently is. How the industry is meeting the Phase 2.

And then I'll be doing sensitivities on that, where I'll be saying, let's assume that no one, everyone did, for instance, for EA-13-109 Phase 2 severe accident capable dry well vent no water addition. What are our costs, and what are our benefits?

And then I would do an assumption that let's assume everyone did water addition. And that's essentially that there would be no costs and no benefits, really, to this alternative. And that's what I'll be doing for everything.

Of course, to our knowledge, no one has elected to install an external filter. So that would not, we would not have to do that type of sensitivity on that. However, depending on what alternative we're talking about with the large filter, and what vent path we kind of talking about.

If we're talking about a large filter that must come off both the dry well vents and the wet well vents, if for some reason, you know, if the licensee chose to not install a severe accident capable vent, well then, there would be significant costs to do that.

That's just a preliminary thought. We're still discuss, we might just end up, it might just be that however you meet EA-13-109 you would have to have a filter off whatever that vent path is.

If you can show you don't need a dry well vent through 13-109, it would only need to be off the wet well vent. We just happen to be looking at both. Like I said, we're still in the midst of the analysis of that. And those are the alternatives that we are evaluating.

That kind of leads us to the rulemaking name change. As you can see, filtration strategies was one of the alternatives within release reduction. And so we just decided to change the name to containment protection and release reduction for BWR Mark I and Mark II containments. As we believe that that's more, it's easier for the public to follow, as well as we believe accurately explains what we're really evaluating within this rulemaking.

And last on the status, as I mentioned, we're developing a draft regulatory basis with significant interaction with the public. We've had

12 public meetings involving the rulemaking. We're developing the performance goals and criteria. And we're completing concurrently developing the various stages of the rulemaking regulatory basis. And that's what I have. Does anyone have any questions?

CHAIRMAN SCHULTZ: Any more questions?

MR. SZABO: Yes.

MEMBER CORRADINI: Maybe just one. So, to kind of go back to Dennis' idea. You had this flow chart of activities. Has this been exercised in a simple manner first, to see -- I mean, I guess the way I usually solve a problem is to try to solve it with the least amount of effort, and go through a process. And see what the process tells me.

So, when you developed the process, without doing a lot of calculations, spend a lot, have you worked through the process and said -- I mean, for example, you go back to NUREG-1150 and Peach Bottom La Salle, do you, Mark I and Mark II. They have containment failure probabilities. They have release fractions.

Can you work the process and say, gee, if I had done something within that context, how would I have changed those results? You see what I'm asking? It seems to me I would, before I run out and do more things, I would establish the process and try to see how it fits within the context of a comprehensive, already comprehensive analysis.

I assume you figure that NUREG-1150 is comprehensive. Maybe it's old, and you don't want to look at it. But --

MR. MOHSENI: I think you will hear about that further in the day, that those kind of insights are there.

CHAIRMAN SCHULTZ: It also seems that there's a struggle ongoing associated with the phasing of the work that will be done on the wet well vent and dry well vent. And given that there are still options there, my question is, has there been --

How much progress, how much progress has there been in achieving consistent understanding about these benefits that would come from implementing the wet well vent and the dry well vent in these various combinations that you've described? Have we come to agreement about what benefits will be gained?

Because even though you say, well, we could go through this, and we wouldn't have a cost or benefit assigned to that if that implementation's going to be done. If you had a criteria that you're trying to meet, and that is for the entire project, then there certainly is a benefit from both.

So, my question is, have we made progress in getting agreement between the regulator and the licensee as to what benefits are going to be achieved by these implementations on the hardened vents?

MR. MOHSENI: I think you will hear more, Dr. Schultz, that there are. What remains to be seen, obviously, is a more comprehensive assessment. But technically, if you look at it just from calculation numbers, yes. There are ways if you make certain assumptions of, if you find yourself in this scenario.

What's the value of having all these systems up and running, and how much reduction do you get in releases? And therefore, public health. You will hear that today in various scenarios. All the work in progress. It's not done yet.

But to the extent that that, you capture all that comprehensively and do cost benefit analysis, at the end of the day that has yet to be done. But the insights you will hear today will give you --

CHAIRMAN SCHULTZ: Thank you. I look forward to it.

MR. MOHSENI: Who's next?

MR. SZABO: Next up is Marty.

(Off microphone comments)

CHAIRMAN SCHULTZ: Good morning, Marty.

MR. STUTZKE: Good morning. I see some new faces on the committee since I've been here. So I'll introduce myself formally. It's always kind of a kick to lay out the whole title.

I'm Marty Stutzke. I am the Senior Technical Advisor for Probabilistic Risk Assessment Technologies in the Office of Nuclear Reactor Regulation.

MEMBER CORRADINI: That's all?

MR. STUTZKE: I'm in the Office of Research.

MEMBER CORRADINI: Seventy-five percent is not bad.

MR. STUTZKE: Being that I work for NRR more than I work for Research. It's like that sometime.

MEMBER CORRADINI: What else do I get on the record?

MR. STUTZKE: Let me begin this by saying, you know, as Aaron had indicated, this is certainly a work in progress. One of you had made, or Aby had made this comment about this like fixing the airplane by flying. And I'd remind you that any landing you can walk away from is a success in that respect.

On a more serious note, we're currently scheduled to complete the risk assessment by the middle of September. I believe the 15th is the deadline Aaron threatened me with. That being said, the process is very dynamic now. There have been changes to the event tree since I provided them to the committee for their review. Sorry, John.

MEMBER STETKAR: It's okay.

MR. STUTZKE: Like that, in fact, we had a public meeting yesterday with industry. And some of the insults, insights not insults.

MEMBER CORRADINI: That I assume was not purposeful?

MR. STUTZKE: That was a Freudian slip. But some of the things that they brought up yesterday has caused me to question, maybe I need to change some of my fundamental success criteria in the tree structure. And I'll point to that right there. And the work that you're about to see has not yet even received internal review within the project team, like that. So, bear that in mind.

Overview. I made a number of notes while you were talking to Aaron about this. And let me try to set the stage here. We're trying to assess the change. Hopefully it's a reduction in risk due to the various CPRR alternatives.

When we originally got into this the focus was on, we'll say external engineered filters. So we wanted to put a device on the end of the vent line that would reduce the release, like that. For various and sundry reasons, that morphed into a more performance based strategy assessment.

Is there some way that you could reduce the release by operating the existing systems, or small modifications to the systems, that would eliminate the need for this expensive external filter onto the system, like that?

As we got further into the process we began to realize the filtration strategies, per se, weren't addressing all of the containment failure modes that are possible. Filtration of primarily the vent lines, severe accident capable vent line is designed to prevent containment overpressure failures, okay.

And then we should ask, well, if I'm venting during those sorts of situations I need to trap the release, like that. But there are other containment failure mechanisms at play that may be more important. The notable one being liner melt-through itself.

If one were to get a reactor vessel breach, and not quench that core debris somewhere into the dry well, it will melt through the dry well. And so, perhaps that's a larger impact, per se. Bearing all of that in mind, with the focus of looking at the benefits of the risk reduction achieved by the CPRR strategies, this is primarily a Level 2,3 PRA issue.

CPRR strategies, per se, do not reduce core damage frequency, okay. That's the role of FLEX, okay. So, if you want to think of it this way, FLEX is accident prevention, and CPRR strategies are accident mitigation strategies. And we're seeking this appropriate balance among the strategies.

However, the equipment, the FLEX strategies, per se, that same set of equipment then would become important, perhaps, in the CPRR strategies. So now you create this enormous potential for dependencies between the Level 1 portion of the PRA, into the Level 2 portion of the PRA.

You'll remember, when I had originally done some work in SECY-12-0159, the initiating event was core damage. That has been replaced by a rather elaborate core damage event tree, just trying to get at the dependencies between system hardware and operator actions, and things like this, into this, to try to get after it.

To answer a question that Mike has posed to Aaron is, yes, I agree. It's always good to use previous work. And we did make another effort to look at this thing. Basically we have some SPAR external event models that are Level 1 PRA types of models. They don't cover very many BWR Mark I and Mark II containment plants, like that.

And the SPAR external event models end at core damage. So, they don't get out into the containment system, which is what we need to be able to get out, like this. We do have some proof of concept SPAR Level 2 models. But they're not external event models. And we don't routinely use them.

MEMBER CORRADINI: When you say they're -- I'm sorry, Marty. When you say they're not external event models, you mean they don't consider what an actual event could do to defeat --

MR. STUTZKE: Exactly.

MEMBER CORRADINI: -- or modify what happens in Level 2?

MR. STUTZKE: Exactly.

MEMBER CORRADINI: Okay.

MR. STUTZKE: They are all internal events for unit models.

MEMBER CORRADINI: Okay.

MR. STUTZKE: Like that. So, in other words, you wouldn't have seismic failure of the containment systems. That's simply not within the scope of those models, like that. Going back to NUREG-1150, there's a couple of reasons why it doesn't want to work too well, from a pragmatic standpoint.

First of all, 1150 was issued or developed before the SBO rule had actually been implemented. There's no credit for the SBO rule in 1150. It's acknowledged in the introductory chapter, like that. Certainly it doesn't reflect the impact of FLEX on core damage or use it like this. There are new seismic hazard curves that have been developed, like this.

And I think, moreover, our knowledge of accident progression, and our tools to be able to analyze that have greatly improved since 1150 was done. In fact, that was the purpose of the SOARCA analysis, to say, we know more about accident progression now.

So, and on a practical note, we don't

actually have the models from 1150. We have the books from 1150. And so, you know, to code all of those backup into our software.

MEMBER CORRADINI: I used that as an example. But your SPAR model discussion I guess I didn't think of. So, thanks.

MR. STUTZKE: Right. I mean, remember, SPAR is designed to support regulatory processes, like significant determination, accident sequence precursors. And they work well on the Level 1 core damage PRA world, like this. Like that. Let's see, what else do we need to talk about?

I think something else that needs to be clarified, or thought about, in terms of these performance, these low performance criterias that Aaron said we're talking about, such as decontamination factor.

Normally when we talk about the Level 3 PRA, we're talking about a direct measurement of public risk. We're talking about the safety goals and their quantitative health objectives, as measured in terms of individual early fatality risk, and individual latent cancer fatality risk.

That's not what he needs for his regulatory analysis. The inputs to the reg analysis are things like population dose risk, person rem per year.

MEMBER CORRADINI: So, what you're kind of saying is, there's no societal risk goal?

MR. STUTZKE: I'm not saying that. We're having it. What I'm saying is, the inputs he needs are not what you normally think of as measures to public health and safety.

MEMBER CORRADINI: Okay.

MR. STUTZKE: Because he needs things like offsite economic consequence, dollars per year. He needs population dose risk, personal rems per year, like this. Decontamination factor, when you think about it, is actually a risk surrogate. It comes out of a Level 2, like this.

MEMBER CORRADINI: But, if I might just ask it again? If the success criteria were based on decontamination factor, and if we had a number that you picked that was a success story, I think you're saying -- It is a surrogate. That makes sense to me.

But it's a surrogate for a goal that doesn't exist. Because the latent cancer fatalities, and early fatalities are not societal risk goals. And everything he mentioned that he'd like to have are just reflections of the societal risk goal.

MR. STUTZKE: Right.

MEMBER CORRADINI: Okay.

MR. STUTZKE: Right. I can accept that. Yes. But it poses the problem when we come out of here as to what is an acceptable decontamination factor, in terms of whatever ultimate goal we're looking at. You need to be able to back calculate.

MEMBER CORRADINI: Okay. But one last point then. So, if the minimization is based on contamination factor, and if the success criteria has some decontamination factor, and that's a surrogate, then de facto we've established a societal risk goal.

MR. STUTZKE: Yes, I see your point. I see your point. Something to discuss next week.

MEMBER CORRADINI: I mean, and thought this, I mean --

MR. STUTZKE: I think I see your point, like that. But to answer another question concerning decontamination factor. And I know industry Jeff Gabor will blow you away with what he's done recently. You know, the original idea of decontamination factor, in my view was, you have an external filter, you put it up on the test rig, and you see what it does so you can measure it.

When you get into the more performance based strategies of water management, or vent cycling, or things like this, the DF achieved is something that's going to come out of a MAAP or a MELCOR type of calculation, to see what you actually get. And they'll show you a very interesting, and very clever distribution function over all the sequences as we achieve DFs. It's very interesting work, like that.

So, it's not the case that we're just saying, okay, I got the source term, and I'm going to whack it by a factor of 100 to account for the DF. That's not how the analysis is actually done.

One more thing on this slide. And we can, I know John's getting eager to get into this. Plans for sensitivity analysis and uncertainty work, like that. One idea is that there's two types of issues, or things that we want to address by this.

One is, how reliable is the strategy itself, any one of these alternatives? These are things like, will the equipment actually work, like this? Will the operators be able to do their job? And we assess that. So that is looking at the uncertainty and the frequency propagated through all the event tree structures, like this.

But there are other issues of uncertainty that I think you're interested in. And that is, given a certain pathway through the even tree logic, how confident we are that we've achieved the DF that we're claiming, or the amount of release reduction we've claimed, et cetera, et cetera, like that.

And these are more, in my mind, related to uncertainty and things like MELCOR and MACCS, than they are strictly the classic PRA types of uncertainties, like that. So, I appreciate the need.

John, you're right. We have not done any sensitivity or uncertainty work yet in the PRA. It is a little premature, since we haven't finalized the HRA at this point in time.

MEMBER STETKAR: Well that, you don't have, other than the hazard curves and the fragility curves that you have, you've not even documented uncertainties for anything else.

MR. STUTZKE: Right.

MEMBER STETKAR: I mean, you haven't even -- I don't know how you're going to treat them. But they're not even there to even take a look at.

MR. STUTZKE: Yes. I understand. We do,

in fact, have the uncertainty parameters for all the hardware related things.

They're just not captured onto the spreadsheet here at that point in time. And I know we will do similar things for the HRA. That being said, I have started some sensitivity analyses already. And it's more from the perspective of debugging the model.

It's always a good idea to set certain numbers to zero and one, and see what you get. Because sometimes you get nonsense. And I think I found something over the weekend that's making me wonder at some --

MEMBER STETKAR: Right.

MR. STUTZKE: -- at that. Okay. So to try to speed this up, we'll talk about --

MEMBER STETKAR: Get through this slide as fast as you can. That's just in one. We want to speed things up.

MR. STUTZKE: Yes, understand. So, we're currently starting out with extended loss of AC power, ELAP as our sequence frequency, like this. And that is a duration of station blackout event longer than the coping time mandated by the SBO rule, like this.

Right now there's two contributors to ELAP that's in there, the so called internal event ones, and the seismic event ones. I haven't estimated the contributions from other types of external events, high winds, floods, and things like that. I'll characterize it, we'll say it's at the edge of our current state of practice in PRA.

In fact, next Monday we're kicking off a rather major research planning process on probabilistic flood hazard assessment to try get at this thing. You've doubtless heard about upstream and downstream dam failures, like this. That there is proposed generic issue on downstream dam failures. But none of those things are included in this.

I don't know that they're insignificant risk contributors at this point. So I have to say, well, they may be significant, they're unquantified. And as such, it constitutes a source of completeness uncertainty, like this.

The other thing that I would point out is that because we have focused on models with only ELAP events, the strategies, the CPRR strategies could be beneficial for other types of accidents. And that's not quantified as well. So it's another source of completeness uncertainty.

So that the quantified benefit from the strategies could be higher than we actually compute, as a result of these completeness uncertainties. And we will treat that, I believe, with sensitivity studies inside the analysis. Okay.

One of the other things that you need to remember is, ELAP frequencies are very site specific. And it's not just due to the external hazards coming in, the earthquake symptoms. Each plant has a specific SBO coping duration, like this. And they have a different number of onsite emergency AC sources, and how those sources are actually provided, diesel generators. And so I tried to account for that in a very crude sort of fashion.

I recently updated the model to use the latest seismic hazard curves submitted by licensees, in response to recommendation 2.1. The exceptions are Columbia and Vermont Yankee. Columbia's seismic assessment's not due until spring of next year, because they're a western U.S. plant. So I'm forced to use their IPEEE data as a basis for that.

During the time we've worked on the project Vermont Yankee announced its shutdown, its closure. And so they didn't submit a seismic hazard curve.

In addition to the seismic failures, and you can see the list of equipment that's in there, we've tried to account for the common cause failures and the random equipment failures.

MEMBER BLEY: Marty? Or maybe it's the microphone.

CHAIRMAN SCHULTZ: Perhaps you can move it between you and Aaron. That might take care of it. But if you hit the cord it will probably -- You've got it. It's a little better. Let's try that.

MR. STUTZKE: Okay. So these are the estimated ELAP frequencies that we have so far, like this. Of course, it comes down, it shows you the Mark Is and the Mark IIs, the isolation amongst these plants. Specifically the EPS class that was defined in NUREG/CR-5500, which is basically the number of onsite emergency power supplies they have, like this, separate, and so on.

But the last four columns are seismic ELAP frequencies in considering the failure of DC power and/or RCIC, like this. The notion being that you can't simply come in with a seismic ELAP frequency into the event tree, because the earthquake affects other equipment besides the ELAP, notably RCIC and DC power.

So, and I was concerned about, there's almost a coupling effect going on here, like that. So you can see this thing broken up.

MEMBER CORRADINI: So, Marty, I saw this, and I --

MEMBER STETKAR: Mike, don't ask. Let me take, let me walk you through this stuff, because there's -- And what I propose, unless, Marty, you want to give some high level discussion of this table --

MR. STUTZKE: Not at this time.

MEMBER STETKAR: What I propose is we take a break now. Because I have, we're scheduled at 10:00 a.m. I have numerous questions that are going to get into sources of numbers, and how this table was generated. And it makes more sense to come back and hit that after the break, I think.

CHAIRMAN SCHULTZ: It does.

MEMBER STETKAR: Things will only start -- And they're interrelated this problem, so --

CHAIRMAN SCHULTZ: With that in mind, and with respect to the schedule, we will come back at 10:15 a.m. So we'll take a break at this time.

(Whereupon, the above-entitled matter went off the record at 9:55 a.m. and resumed at

10:14 a.m.)

CHAIRMAN SCHULTZ: If I could call the meeting back to session. Marty, we're going to continue with your presentation. And we're going to answer on this question why this is a joint meeting between the Fukushima Subcommittee and the Reliability and PRA Subcommittee.

But let's start where you left off in terms of the presentation on core damage of entry.

MR. STUTZKE: Right. Before we get in, I'll actually put up the event tree structure itself. It's rather large, it's seven pages, which makes it pretty difficult to review. I was just thinking I have my ten year old daughter helping me cutting and pasting to glue the pages together.

MALE PARTICIPANT: Question on Page 6.

MR. STUTZKE: Just for sequences. I'm sure. But before we get into the actual thing, I wanted to give you a general view of this. This is a general model of FLEX strategies, Phase 1 and Phase 2. So that's up to the point when the offsite response capability would come into play.

What used to be called the Regional Response Center, so now they're the National Response

Centers, the ones located in Memphis and Phoenix. So you might bear in mind when they talk about the NRC's going to come and save the plant, that that's the other NRC. Right, that's the National Response Center and not us they've got.

In order to start the logic model development, I actually reviewed all of the SBO mitigation strategy submittals that licensees had provided. And what you find is there is a large variation in approaches of implementing FLEX from site to site and among the different utilities involved like that.

You know, it indicates FLEX's performance based, the joke is it's very flexible like that. But in order to make the model more attractable, we have a generic model here for BWR Mark 1 plants with RCIC systems like that.

And so we're modeling, basically, the portable FLEX pump, as well as emergency generators to supply DC power to the batteries, again, recharge batteries like this.

There are so called anticipatory containment vending strategies considered into the tree. The idea is that we're talking about an extended loss of AC power like this, in order to have a remover pathway out of the containment, you need to vent in order to vent containment over pressure failure.

The idea, anticipatory vending has to do with these performance based strategies that says in general we want to keep the suppression pool as cool as we can so that should we evolve into a core damage accident, its filtration capabilities are enhanced like this.

And so by anticipatory, what they mean is venting well before the primary containment pressure limit is reached. Sometimes as low as, normally 15 pounds.

MEMBER CORRADINI: Gauge?

MR. STUTZKE: Psig. Some of the strategies, actually, I think there's been some work done at five pounds, like this. So that's included into the tree structure like this. The requirement by the current ABG SAG is to re-close the containment vents upon the occurrence of core damage. It's considered in there.

Consideration of local manual operator actions upon loss of DC power such as RCIC, black start and run, local manual safety release valve operation, and local manual containment vent operation.

There are many other human failure events included into the model. You know, failure to align the flex pump, failure to align the emergency generator, so forth and so on like this.

For the purposes of building the tree structure itself, placeholder types of events, I've currently assigned numbers for all human actions that occur in the control room at 0.1, and outside of the control room at 0.3. James Chang is in the process of refining those numbers, but they're good enough to let us develop the logic structure.

They are screening only in the sense that they have helped us in the selection of the MELCOR calculations, the focus on which sequences we think are more important than others like that. Again, all preliminary.

The tree itself, as I pointed out, it's very large. There's 320 total sequences of which 280 go to core damage like this. So without further ado, this is the actual event tree structure like this. It goes down.

Going across the tops of the trees, we have the ELAP event and the Phase 1 events. And here, Phase

1 events being DC power. And RCIC recall Phase 1 as your reliance on your in-plant systems to do the job like this.

Then there is an event here for rack pressure, depressurization. The idea is they want to get down between 200 and 400 pounds in order to minimize the heat up of the RCIC pump. So extend the RCIC pump operation like this. So forth and so on.

Phase 2 DC power begins to pick up the recovery from the emergency generators like this. These are the anticipatory venting strategies being considered in here. Failure of just the RCIC in Phase 2. If RCIC succeeds, the notion of the tree is there's need for some long term suppression pool makeup to make up the evaporative losses like that.

Only if RCIC fails does the tree then begin to question the portable flex pump itself as a way to provide direct reactor vessel injection like this.

Let's flip over a little bit to the calculations. I'll point out, these are the only seismic events in the tree, right here. The ELAP frequency, the seismic failure of DC power in Phase 1 and the seismic failure of RCIC are in here.

None of these, these events are all

independent of the magnitude that hits because they're mainly operator actions going on here or failures of the portable flex equipment itself like that. The exceptions would be failure --

MEMBER STETKAR: Marty, you're kind of bouncing around here. And I don't know quite how to start the discussion. So if you want to talk about the event tree first, that's fine. If you want to talk about where the numbers came from first, that's fine. But we're going to talk about all of them.

So which would you prefer to talk about, your choice. Entry would be good, since you have it up there. I think I understand the event tree. I actually went through the event tree. I understand the philosophy of the event tree. It makes sense.

As you mentioned, there are a lot of human errors in there. I'm not going to dwell much on the human error probabilities because they're bogus. go down to sequence 101?

MR. STUTZKE: What?

MEMBER STETKAR: Bogus. There's no dependencies evaluated. The same human error probability applies regardless of whether it's seismic damage or hardware damage. Same human error probability applies after and preceding.

MR. STUTZKE: I didn't hear what you said.

MEMBER STETKAR: They're just numbers. Hundred and one, I only had one question, actually in the event trees. Oh, you changed it. Oh no, it's still up there actually. Why is pressure low, and this applies to any of the sequences where you have inadvertent depressures where you have a failure of P1, so you have inadvertent depressurization and then failure of all vent paths.

Those sequences, so the P1 down, WW down, DW down are uniformly mapped to a low pressure at the time of melt. And I don't know why that's low pressure. I think I got all of the other pressures, but I don't know why that's low pressure, in other words, why it's not median pressure.

I understand the other ones because you got vents open in the other cases at some point or another.

MR. STUTZKE: Yes, the failure that's being modeled is, as I had said before, they're trying to target at 200 to 400 pound pressure to extend the RCIC operation.

MEMBER STETKAR: I understand that, and

they go too far.

MR. STUTZKE: And they go too far.

MEMBER STETKAR: RCIC goes away.

MR. STUTZKE: So RCIC fails.

MEMBER STETKAR: Right.

MR. STUTZKE: And they're centrally depressurized.

MEMBER STETKAR: They are at that point. But they're also bottled up. So I don't have a wet well dent open and I don't have a dry well dent open. So the entire enclosed system is still bottled up.

MR. STUTZKE: It ought to re-pressure.

MEMBER STETKAR: It ought to re-pressurize.

MEMBER CORRADINI: But when you say re-pressurize, I thought the level you were just talking to him about was larger than what would be allowable, but it would almost self vent. The dry well would self vent way before those pressures you were just talking about.

MEMBER STETKAR: Dry well would self vent where?

MEMBER CORRADINI: Well, I mean, if you're going through the logic of this, you would expect there would be some sort of self venting through the flanges or through a broken seal or a bellows or something.

MEMBER STETKAR: It's not modeled here.

MEMBER CORRADINI: I thought it was.

MEMBER STETKAR: My only question on all of those sequences, and that's sort of the point. When I looked at the end states, I didn't understand why that pattern, and maybe it was a good story, but why that pattern wasn't mapped to a medium pressure rather than low pressure null. I could handle a medium pressure.

MEMBER BLEY: What's lower limit on medium pressure on that?

MEMBER STETKAR: It's either a couple of hundred -- it's sort of in that 200 to 400 pound range.

MR. STUTZKE: The notion is medium pressure defines a state where you're above the shut off head of the portable FLEX pump.

MEMBER STETKAR: Right, okay, yes. So it's, I mean, in a way it works out. It's sort of in that couple of hundred, few hundred pound range. Great. So anyway, in terms of the event tree structure and the end state assignments, that's the only thing

I've actually stumbled across, and I don't even know whether it's real. But it's worth thinking about. There's only about, I don't know, there's eight, there's sort of an eight fold replication of this stuff.

And I didn't actually have any of the -- you said you changed the event tree, but you really, did you change the event tree since the picture that we got?

MR. STUTZKE: I haven't changed the core damage event tree. And it's actually on the assignment of the release categories. The logic structure is what it is.

MEMBER STETKAR: Okay, I ran out of steam, so you're lucky on that. I didn't look at those very much.

MR. STUTZKE: Yes.

MEMBER STETKAR: Okay, you haven't changed these. That's good, because I sort of got this.

MEMBER CORRADINI: So can I, I'm sorry that I'm going to just, because now you guys are on the same page but I'm off the page. But it would seem to me that, if I understand your question, John, you go from P1 down, down, and you don't vent. Isn't it going to self vent so that's a failure?

MEMBER STETKAR: Self vent where, to where?

MEMBER CORRADINI: To the outside world, to the environment.

MEMBER STETKAR: From what?

MEMBER CORRADINI: Well, I mean --

MEMBER STETKAR: At the time of core damage. At the time, what is the pressure mean reactor vessel at the time of core damage, not after core damage. At the time of core damage.

MEMBER CORRADINI: But isn't the pressure in the reactor vessel now, since I've already pre-opened it, the same --

MEMBER STETKAR: Pre-opened it where?

MEMBER CORRADINI: Into the wet well and dry well.

MEMBER STETKAR: You pre-opened it into the wet well.

(Simultaneous speaking)

MEMBER STETKAR: To the wet well. And the wet well is sealed.

MEMBER CORRADINI: Right.

MEMBER STETKAR: The pressure of that communicates to the dry well. And the pressure of the dry well is sealed.

MEMBER CORRADINI: Right.

MEMBER STETKAR: So what is now the pressure in that entire intercommunicated --

MEMBER CORRADINI: It's communicated by the fail mechanism of that system to the outside world.

MEMBER STETKAR: Okay, well that --

MEMBER CORRADINI: Two hundred pounds.

MEMBER STETKAR: It will fail below 200 pounds?

MEMBER CORRADINI: Yes. Yes. Absolutely. I think we have empirical evidence to that effect.

MEMBER STETKAR: Well see then --

MEMBER CORRADINI: Unless I'm misunderstanding --

MEMBER STETKAR: Then the entire allocation of some of these pressures is wrong, because what you're saying is you never get a medium or high pressure melt. You're saying you never get a medium or high pressure melt.

MEMBER CORRADINI: I guess I'm just, you've looked at this and so I just wanted to clarify in my mind that if I've communicated the RPV to the dry well and wet well, they're in communication. So whatever the pressure is is dominated by what's happening in the dry well and wet well.

MEMBER STETKAR: Okay.

MEMBER CORRADINI: And unless I misunderstand the limits, I'm trying to remember back, you would essentially, I don't know of any Mark 1 at least that can stand the pressure of 200 psig without starting to self vent from somewhere because of high pressure and temperature.

MEMBER STETKAR: Well, and if that happens, then all of our vents --

(Simultaneous speaking)

MEMBER STETKAR: This is important because if you account for that, then the pressure assignments here are not correct, and our control vent doesn't do anything. Right?

MEMBER CORRADINI: Well, I was hoping to stimulate somebody who knows more than I.

MR. TRUE: I mean, yes, I don't know about --

MEMBER STETKAR: Identify yourself, please. Although we know you.

MR. TRUE: Am I on?

MEMBER STETKAR: You're on. You may have to --

MR. TRUE: This is Doug True from ERIN. I don't know Marty's vent tree maybe the way you do. But as I understand the scenario, we have DC power available, and the SRV's have been functioning. And the operators control pressure too low, which ended up causing loss of RCIC.

MEMBER STETKAR: Right, that's correct.

MR. TRUE: So now we have no injection.

MEMBER STETKAR: Right.

MR. TRUE: Procedures would tell the operators to close the SRVs.

MEMBER STETKAR: Yes.

MEMBER STETKAR: The RPV boiled down, and when you reach the minimum steam cooling water level, or some other like that, then they would de-pressurize the RPV. So at the time of core damage, you would be at low pressure.

MEMBER STETKAR: Okay.

MR. TRUE: In a case where you have no DC power, then you would be at high pressure because it would return --

MEMBER STETKAR: Yes, in the no DC power.

Well actually, no DC power's also go to this stuff because they take credit for people cranking valves locally. So this model has, if no DC power is available, people run it up, that's a different question.

Run out of the plant and grind valves locally. But the question is one way of doing this is the operators didn't do what you said. They didn't control pressure.

MR. TRUE: But his entry condition is they controlled pressure too low.

MEMBER STETKAR: Well, when you say they controlled pressure too low, they didn't control pressure the way they were supposed to control pressure. It went too low.

MR. TRUE: Right, it went too low. So it's low.

MEMBER STETKAR: It is low. It is right where the thing is highlighted there, at that point it is low and RCIC isn't working anymore. So you have no make up.

MR. TRUE: Right.

MEMBER STETKAR: Okay.

MR. TRUE: So why would it go back up?

MEMBER STETKAR: Why wouldn't it go back?

MR. TRUE: Why would it go back up?

MEMBER STETKAR: As you start to uncover fuel because you have no make up, you're going to pressurize now the entire integrated system, aren't you? Where are you getting --

MR. TRUE: This is early the scenario, right, Marty?

MEMBER STETKAR: Yes, no, this is, eventually we have now molten core.

MR. TRUE: Right, and we're only a few hours in. You wouldn't depressurize containment to 60 plus pounds at only a few hours in.

MEMBER STETKAR: At the time of core damage, Doug.

MR. TRUE: At the time of core damage.

MEMBER CORRADINI: I mean, you can do the calculation. The capacity, assuming the sequence is as they suggest, it's still going to be kind of cold. So the vapor pressure you're going to add to the inert gas in the dry well is not going to be anywhere near any new pressures, okay.

MEMBER STETKAR: Okay. That's fine. I would just question, that's the only place where I was questioning that pressure. And if there's a DC, I can't boil water. If there's a DC explanation for why it would be in that whatever's the defined as the low range, then I'm good. I mean, that's the only end state that I was questioning the pressure on.

So if you think there's enough heat capacity out there such that by the time you start actually melt fuel, you're

(Simultaneous speaking)

MEMBER CORRADINI: It still marches on. The whole three groups of the system will rise.

MEMBER STETKAR: See, that was my concern, that I don't know the relative timing of that whole three groups of the system rising, and how that low pressure condition is translated back into the accident progression of vent trees. I just don't know why, I mean, you know?

MR. STUTZKE: But the way that this is intended to work is following sequence 101 down here. What it says is my pressure is low enough that if I recover or get the FLEX pump aligned post core damage, it will inject because --

(Simultaneous speaking)

MR. STUTZKE: -- into the system.

MEMBER STETKAR: How soon do they have to get it for that to be the case?

MEMBER CORRADINI: But again, I'm dealing with this only from the processes. My understanding is, and I'm not Doug, is I don't have any Mark 1 that can generate a high enough pressure with the coupled system all open to each other that would --

MR. TRUE: Not in the early time frame.

MEMBER CORRADINI: Not in the early time frame, but that would cause a pressure that you couldn't inject.

MR. TRUE: Yes, you need the hydrogen and you need the pool saturated to get you out into those pressure ranges.

MEMBER CORRADINI: Okay.

CHAIRMAN SCHULTZ: So that resolves your part of the discussion with regard to the median pressure --

MEMBER CORRADINI: I just wanted to make sure I understood John's question, that's all.

MEMBER STETKAR: And that was my, like I said, I don't, other than that I got the tree and --

MEMBER CORRADINI: John is the pro when it comes to the event.

MEMBER STETKAR: Well, event trees. But I'm not the pro on energy, and especially not on a boiler, energy balances and timing. But now, that's the only question I had on the event trees, Marty.

But if the other members now want to talk about the different functions in the structure, that's fine. I'll be quiet because I understand how you've laid out the event tree, but they may not.

MR. STUTZKE: Other questions? Let's talk about the numbers.

MEMBER STETKAR: Okay. Go over to your Browns Ferry spreadsheet. Only, this is not unique to Browns Ferry. It's just we'll start there.

MR. STUTZKE: They're all the same.

MEMBER STETKAR: They're all the same. Let me ask first just what I think may be a simple numerical thing. If you look at what you're designating, if you look at cell I-9, see the equation for that. I-5, I-27, I-15, and again a couple others.

But then I-15, see it's got I-27 in it. Why are you multiplying seismic failure of all site power by itself?

MALE PARTICIPANT: That's a real good question.

MEMBER STETKAR: I'll just raise that. You don't have to answer it now unless there's a really good answer really quick.

As best as I can tell on any of the sequences 112 through, in the top half of the tree where you're using 1 to 113, you're multiplying that seismic failure of offsite power twice because you're treating those top, you're treating those four, what's characterized now as 1 through 112, 113, 1.2 to 116 and whatever, I can't speak very clearly. Those are four initiating event frequencies, right?

MR. STUTZKE: Right.

MEMBER STETKAR: You hit the tree with those initiating event frequencies. You toggle those top events up and down depending on whether or not --

MR. STUTZKE: No. It's because these numbers aren't actually used later in the calculation.

MEMBER STETKAR: They are, because they're used for the frequency of Line 9 and 10. Forget the SELAP because that's just a sum. Go down to the next 9, I-9. That says the frequency that gets --

MR. STUTZKE: Seismic initiator.

MEMBER STETKAR: Seismic initiator and off site power is lost, and off site power is lost, and on site power is lost. Off site power doesn't need to get lost twice because I-15 has got I-27 in it.

Essentially, in that equation on 9 and 10, 10 is also, you're multiplying I-27 by itself.

MR. STUTZKE: Yes, I see the problem.

MEMBER STETKAR: Okay. The good news is they tend to be fairly high numbers at points. By the way, if you take it out, it makes some numerical difference at the point, but not a heck of a lot. The other stuff that I'm going to talk about might make more of a numerical difference.

I couldn't figure out where the numbers are coming from, so you need to walk through the spreadsheets if you don't -- okay? So that's a comment. Take a look at that.

More importantly, pull up so we can see, like, 20 through 30, lines 20 through 30, just so they're in the center of the -- there we go. That's good enough.

Now, I think my biggest question may be what's -- I'll let you stop highlighting things. What is the technical basis for these really, really rugged pieces of equipment? If I look at the switch gear, the batteries, AC/DC switch gear, batteries, diesels and RCICs, seismic fragilities, the median capacities, especially of the switch gear, are 3G. That's the median capacity.

That is really, really, really, really, I'll stop there, rugged equipment. Much more rugged equipment than I've ever seen in any plant where people have done plant specific fragility analyses.

And the uncertainties are in those fragilities are, let's call it sort of a standard uncertainty, a beta c on the order of about .45 to -ish is sort of, you know, a modest uncertainty.

So my curiosity is where the heck did you get these really rugged fragilities? Only as a reference that says they were taken from the RASP Handbook Volume 2 Table 4(d)1. But, you know, I don't know what that is.

I've got fragilities, there's a NUREG that developed fragilities. I've got fragilities from several site specific analyses that I can't share, unfortunately. But things like switch gear tend to have medium capacities in the -- it's very site specific is the problem because it's mostly anchorage.

You're talking about stuff that's fairly tall, fairly thin, and some places they're tack welded into embedments in concrete, some places they're bolted. So the variability from plant to plant varies quite a bit.

And most of the failure modes that we've run into is ripping out the embedments and either the stuff toppling, or pulling out cable connections, you know, because if it's not top braced, and very few of them are, you get a motion like this.

And the median capacities that I'm used to seeing for switch gear are on the order of a g to maybe two g's, not three. Now why does that make difference? And because of this variability that I've seen, if I'm applying this stuff generically, a much broader uncertainty. Essentially a much broader beta u because of the site to site variability, not the beta r for a given set of switch gear.

Now why does it make a difference? Well, if I look now in your models for the plant specific seismic failures, take AC switch gear, the HCLF capacities in your models tend to be about 1G. In other words, at 1 g acceleration, there's only about a one percent probability of failure.

If I knock down that median capacity to something even on the order of 2 g and kick up beta c now to something on the order of about .7, I get that

HCLF capacity down to about .3 g, which in your seismic hazard curves is roughly two orders of magnitude in the frequency of where you start to see seismic failures. So it's a big deal.

You know, something that starts to, people weren't used to this stuff, things that start to sound like small numbers, what's the difference between a .46 and a .8 or .75, well what's the difference between a median of 3 and a median of 2 or even lower can make huge differences in those frequencies.

So I would really like to understand where those fragilities came from. Yes, I think that could change, if they're optimistic, I think that could change the picture substantially.

MR. STUTZKE: Okay, the RASP Handbook is the set of information that the senior reactor analyst, the SRA's use in conducting STP evaluations. Okay, I will go back during lunch and hunt down the specific --

MEMBER STETKAR: Yes. That's why I wanted to get some of these --

MR. STUTZKE: This NUREG CR this comes out of, it's like that, yes.

MEMBER STETKAR: So that, of anything that

I'm going to be ranting about here this morning, that one is the thing that has the potential, I think, of changing the complexion of the whole quantitative part of the front end stuff.

MEMBER BLEY: And this really would look like some that are top anchored, as well. I mean, this is pretty stout.

MEMBER STETKAR: Oh, yes. I mean, we've looked at stuff that had been built, I can't, we looked at stuff that's been built for missile protection. And even there, you have median capacities in the two to two and a half range.

MEMBER BLEY: Oh, is that right?

MEMBER STETKAR: Well because, yes, because of the anchorage of the stuff.

MEMBER BLEY: Okay.

MEMBER STETKAR: Enough ranting on that.

MR. STUTZKE: No, I'm just wondering now, thinking about it, I appreciated whether these are what I call local accelerations without propagating it up to the floor response.

MEMBER STETKAR: But, see, the problem is though that the median, the capacities that I'm looking at, the guys were just looking at the equipment also.

It didn't have any of the building response in it either.

This was just simply, you know, seismic, the EQE SMA, whatever you call them, guys looking around looking at anchorages, looking at the masses and applying an acceleration there, without structural amplification or anything. It was just, you know, looking at anchorages, embedments, and masses.

Let me go on. So I've got that. I talked about the seismic failure bins and the HCLF capacities. Now, another question I had is, so I went back and I said well gee, you know, the last seismic analysis you guys showed us was the spent fuel pool study.

And in the spent fuel, and recognizing you were actively trying to be really conservative in the spent fuel pool study, but not, at least my understanding in the seismic damage to the fuel pool, not absurdly conservative.

There, you were assigning, depending on the particular plant, you only looked at a .7 g and a 1.2 g earthquake. You had a best estimate, a low estimate, and a high estimate of failures. For your best estimate failures at .7 g and 1.2 g were in the measurable probability range on the order of .1, .5

in some cases.

If that's the case and the equipment is so rugged, why aren't you modeling structural failures? And structural, if the structures have comparable fragility, capacities to this really rugged equipment, that also could change the whole nature of the treatment of human performance because if I have to bring in a front end loader to move the debris around to get to stuff that I want to operate, that's not a good day in the power plant.

So if these equipment capacities are somehow justified, I don't know why you're not looking at structural fragilities because they could be comparable.

MR. STUTZKE: Yes, I understand the problem. I understand the issue there.

MEMBER STETKAR: If these were much, much less rugged, I might let you slip on the structures. So that's another question about the structures. If you're taking notes, tell me, just take notes and I'll stop.

MR. STUTZKE: No, I agree. When you discard failures out of it, you simply don't model the, then you're relying on the fact that you string them up really and put in what's right.

MEMBER STETKAR: Now, you got enough notes? You mentioned that, and it's true, that the seismic failures that are modeled in, that are included in the model is the AC power sources, DC power sources, diesel generators which are tied into the AC power sources, and the RCIC pump itself.

Why don't you model seismic failures of FLEX? This gets back a bit to the structural stuff because the FLEX stuff on site is stored in structures that are supposed to be designed to meet the safe shutdown earthquake. Let me call that something on the order of, oh I don't know, .15 or .2 g.

We're not picking up failures of this rugged equipment until something on the order of beginning 1 g. So why do I know that the FLEX equipment, I don't need the front end loader to go dig the FLEX equipment out of the pile of rubble?

CHAIRMAN SCHULTZ: I thought I saw that was considered.

MEMBER STETKAR: It is not. No, not seismic failures of the FLEX.

CHAIRMAN SCHULTZ: It's not, okay.

MEMBER STETKAR: The FLEX pump can fail

by itself, the operators can fail to connect it, but the FLEX pump is perfectly available, and the portable diesel generator on, anything on site is perfectly available after a seismic event except for its own hardware failures and human errors.

MR. STUTZKE: The only thing that's modeled in FLEX is the random hardware failure of the vent itself.

MEMBER STETKAR: Okay, so that's another question. Should hardware, potential hardware damage that if not disables, at least delays operator access to that FLEX equipment be considered?

Got it? Let's look at our Line 25, hardware failures of the emergency diesel generator. These are, and I'm not going to argue with the failure rates because I know they're from the recent update, so I'll take that as something that you can trace back to some actual hard data.

Although those are really good diesels, you know, as diesels have improved, and I'll give you that. On the other hand, since the hardware is so good, these things better never be out of service for maintenance because it strikes me when you start looking at the hardware failure rates that a maintenance unavailability of one shift, eight hours per year would be about, oh, three times higher than the hardware failure rate of the diesel to start.

And this model you have here only accounts for really one diesel. And I think you get away with, it doesn't account for multiple diesels. It's just got a single diesel failure. But given the fact that that's the way you want to structure the model, again, if this hardware failure rate was 10^{-2}, I wouldn't worry about maintenance unavailability.

But a maintenance unavailability of one day here gives me 2.7×10^{-3}, which is much bigger than the sums of these things.

MR. STUTZKE: Okay, to my understanding though, these are not just strictly the diesel failures. This is a fault tree model of the tower system as a whole. So it includes --

MEMBER STETKAR: Well, if that's the case, then I'm really curious how maintenance was modeled if this is the result of a fault tree model. I was assuming this was only hardware failure starting on hardware failures.

MR. STUTZKE: No, it shouldn't. It's my understanding this is the complete system.

MEMBER STETKAR: Okay.

MR. STUTZKE: What they use for industry terms and performance indicators and things like that.

MEMBER STETKAR: Okay. Well, I'd like to understand that. If this is indeed the result of a fault tree model that has more than one diesel and accounts for, you know, all the combinations of independent starts, common cause starts, maintenance, you know, start run, all that kind of stuff.

The reason is they're characterized as start only failures and run only failures. So I don't see start runs and I don't see maintenance runs and I don't see common causes. So, I mean, the way these are treated is they're treated as a Q and a lambda. I mean, the maintenance run, sure, it's 10^{-4} x 72 as if it's a single piece of equipment.

So if this is a fault tree result, if 25 is treated as a Q fail to start, which it is, and 26 is treated as a lambda fail to run, which it is, the other combinations of start runs, maintenance runs, you know, maintenance starts, all of those cross product things, if these are derived from some type of model.

(Off microphone comment)

MEMBER STETKAR: And the last one I think, excuse me, that I have, you know, your model runs after 72 hours. That presumes then that at 72 hours, FedEx drops the stuff in the site, right?

MR. STUTZKE: Right.

MEMBER STETKAR: Okay.

MR. STUTZKE: And I --

MEMBER STETKAR: That's the contention on this because otherwise, if FedEx doesn't drop the stuff until five days after the event, you know, you ought to have a little more mission time in there. But this whole model presumes that FedEx, offsite, regional support center stuff drops in at 72 hours.

MR. STUTZKE: NRC.

MEMBER STETKAR: Right, the other NRC. Now, if I go back, my benefit is I have all of this stuff written down for me and I can read it. So tell me to slow down when you want.

MR. STUTZKE: I thought I had reset it with the 24 hours, though.

MEMBER STETKAR: What?

MR. STUTZKE: I recently reset this to 24.

MEMBER STETKAR: Oh. I had basically a question of why isn't it, like, seven days. Why is it 72? If you reset it to 24, that means the posse drops the stuff in at 24.

MR. STUTZKE: Yes, it's been some, I guess, debate within myself. You know, the FLEX plans say they will respond, the National Response Center should be on site within 24 hours after receiving the call.

MEMBER STETKAR: Yes, but they don't receive the call until this stuff fails.

MR. STUTZKE: No, it's all at one hour into the sequence. They make a declaration of ELAP within one hour.

MEMBER STETKAR: ELAP doesn't happen, though, until the diesel stopped running.

MR. STUTZKE: I see.

MEMBER STETKAR: Or the FLEX pump doesn't deliver flow anymore.

MR. STUTZKE: I see.

MEMBER STETKAR: It works okay if you say I've bounded this bad word, don't use the word bounded.

MR. STUTZKE: It's not in my vocabulary.

MEMBER STETKAR: No. And I try not to use it. I now have to go beat myself up, which many people will be happy about. But as a boundary condition for this model you say that it's going to assume that the posse will be called in at 72 hours, that's okay. I mean, we can discuss that, but that's okay.

Saying that the stuff only has to run for 24 hours I think troubles me a bit in that sense. By the way, I ran them out for seven days, and it tends not to add very much either, so it's not. But it's a philosophical issue, you know. Especially if you're --

MR. STUTZKE: I understand.

MEMBER STETKAR: If you're moving the mission time in the other direction.

MR. STUTZKE: The philosophical issue, you know, we're trying to model up to the end of FLEX Phase 2, and it doesn't stop when the cavalry arrives.

MEMBER STETKAR: Right.

MR. STUTZKE: Because there's further action to actually unload, you know.

(Simultaneous speaking)

MEMBER STETKAR: There's a lot of gray in timing out there. So I think you have to just set --

MEMBER BLEY: I've got a question because I haven't studied the plans for implementing FLEX, at least not in a while. Given you're in a situation where they're having to put their own FLEX equipment into play, do they preemptively ask for more as backup, or do you wait until it fails?

MR. STUTZKE: No, my understanding was they will call right away.

MEMBER BLEY: As soon as you know you're going to need your own FLEX equipment, you go for backing it up?

MR. STUTZKE: Right. I mean, it's my understanding that, and industry's welcome to jump in at any time, but when you look at the time lines for this thing, for their scenarios, and the back of every submittal has a time line.

So ELAP occurs at time zero, and the declaration of the ELAP which starts the clock for all of these actions is within one hour. Okay, but in fact you haven't had an ELAP for, right, because you've had a one hour SBO.

MR. BOWMAN: I'm Eric Bowman, I'm a special advisor and the technical support director in the Japan Lessons Learned division. All of the integrated plans for the mitigating strategies order for which the industry response is FLEX call for a call from the licensee to the National Safer Response Centers, which is the new name of the Regional Response Centers, to provide the equipment upon the declaration of an extended loss of AC power.

And the typical time at which they postulate that they will declare that they are in a condition that is an ELAP is one hour after the initiating event. The NSRC's have a 24 hour from notification period in which they're supposed to provide the equipment.

The equipment is typically backup equipment to the equipment that is stored on site. There are some unique sets of equipment that are stored in the NSRCs that are not maintained on site such as water treatment equipment and things like that.

In our discussions with the NSRCs and their subcontractor for the delivery of the equipment, which is the FedEx Custom Critical, typical capability barring complete disasters is well within the 24 hour period.

MEMBER STETKAR: That's all I have where this is sort of -- go back to your slide on the, it's in here someplace, but that slide that I shut you down on that's got the numbers in it. Yes, there you go.

Now, one thing that I noticed, given the fact that the seismic ELAPs, now you can come back to this slide. The first thing that got me curious about this is that in general, if you look at this, the seismic extended loss of AC powers are really small. I mean, they were much smaller than I expected to see them given what I thought capacities and stuff.

So that's why I got over to the spreadsheet. Now let me go the other way. If those indeed are justified, if they're that small, that means that the internal, what's called now in the column that's called internal hazard ELAP is the most important thing that's driving all of this.

And that's important because those are hardware, I mean, the stuff isn't physically damaged. So when you hit the event model with that, that's a boundary condition.

The thing that was curious to me is that we've got, I don't know how many units are lined up here, 20 some-odd or something like that. We have five numbers for something now that, at least in this version of the model, is the most important contributor to extended loss of AC power.

But only five month numbers for the entire fleet of BRWs. One of those numbers, 5.0×10^{-6} is uniquely associated with Peach Bottom because, I guess, that's the most unique plant in the world and we know everything about that.

So let me throw that one away. The other four numbers are 7.3×10^{-7}, 6.6×10^{-6}, 9.9×10^{-6}, and 1.3×10^{-5}. We have site specific seismic hazard curves for each of these units. So you treated site specific seismic hazard.

We have generic fragilities. But out in the seismic end, you try to differentiate among each unit, each site with a site specific hazard. Why do we only have four different numbers of internal event extended loss of AC power?

MR. STUTZKE: Because these are coming out of NUREG CR-5500.

MEMBER STETKAR: No, no, no. I don't care about NUREG CRs whatever. That's somebody else's stylized thing. You already admitted that the seismic models are not relevant for old stuff.

So why is Browns Ferry Unit 1, Unit 2, Unit 3 the same as Fermi?

MR. STUTZKE: Because it's --

MEMBER STETKAR: I know that they have many more diesels at Browns Ferry. And I know they have different numbers of diesels between Units 1 and 2 and Unit 3 because of the way the plant is designed.

MR. STUTZKE: It's due to which EPS class that's assigned to it.

MEMBER STETKAR: So these are just stylized numbers?

MR. STUTZKE: Yes.

MEMBER STETKAR: Even though in this format of the model they're dominating the whole issue here?

MR. STUTZKE: Yes.

MEMBER STETKAR: Ah. I thought that the NRC staff has models for every single --

MR. STUTZKE: SPAR models.

MEMBER STETKAR: Yes, SPAR models that are indeed a direct representation of each unit. Why didn't you use those models for internal hazard ELAP, so that I have 20 different numbers instead of four?

MR. STUTZKE: Yes.

MEMBER STETKAR: And these Geiger count for things like internal fires or internal flooding --

MEMBER BLEY: You're saying that the internal's dominant. The internal's a lot higher, but it doesn't lead to --

MEMBER STETKAR: It may not --

MEMBER BLEY: It doesn't cause the consequent failures of the DC and RCIC, or that their seismic.

MEMBER STETKAR: That's correct. Dominant in terms of initiating event frequency here, not necessarily dominant through the entire event model. But my point is that if you spent, and they have, I mean, they spent I think other than the generic fragilities that I brought up, a good effort to develop site specific hazards for seismic hazards for each plant.

MEMBER BLEY: Can we turn the question around a little for Marty? In the results you're now seeing, are the seismic situations dominant in terms of results, or is it kind of mixed with the internal hazards?

MR. STUTZKE: No, actually I think the seismic's important, and I'll explain in a few more slides why I think that's the case.

MEMBER BLEY: And it might be that seismic's much more important, so it's more worth.

MEMBER STETKAR: But that may be because there's no distinction on the human error probabilities other than some human actions are precluded.

MEMBER BLEY: That's true.

MR. STUTZKE: I'll show you a sensitivity study where I set all the HEPs to zero.

MEMBER STETKAR: To what?

MR. STUTZKE: To zero.

MEMBER STETKAR: To zero.

MR. STUTZKE: Just to looking at the hardware contributions.

MEMBER STETKAR: Okay. Oh, okay. That's by the way for the rest of you. That's all I have. I'll be quiet now.

MR. STUTZKE: No, I do appreciate you looking at it. It's like I said, nobody's gone into this level of detail.

MEMBER CORRADINI: You wouldn't expect less from him.

MEMBER STETKAR: The reason I won't say anything more is when you burn two and a half days going through this stuff, you run out of time.

MR. STUTZKE: Let me bounce over, if I can, to Slide number 8, which are model results. And these are looking at conditional core damage probabilities that are currently projected.

And to some extent they're bogus in the

sense that they have these placeholder human error probabilities in there like this. We're trying to give you a flavor for the types of insights like this.

MEMBER STETKAR: This is interesting, but in terms of what Dennis brought up, the CCDPs are certainly higher for the seismic events, but they're not dramatically higher. You're not seeing the difference between .01 for internal hazards and .5 for example for seismic.

MEMBER BLEY: They're close enough.

MEMBER STETKAR: They're close enough such that the --

MEMBER BLEY: But the argument I suggested isn't worth --

MEMBER STETKAR: Yes, there you go. Right.

MR. STUTZKE: Doesn't quite cover it. Let's see. So this is a tabulation of the significant plant damage states for the, well first of any strategy coming out of here. The average, when I say, total CDF. This is the population average CDF coming through here.

MEMBER STETKAR: Yes.

MR. STUTZKE: Like this, and one thing that

I noticed that has created modeling issues, I mean, it's in the extent of the models is this risk profile is reasonably flat. There's a large number of plant damage states, 45, that are significant in the sense that they contribute up to 95 percent of the total CDF, even though the individual contributors, if you look down on the right hand side, are all less than one percent.

MR. STUTZKE: Yes.

MEMBER CORRADINI: I'm sorry, Marty. Can you just repeat that?

MR. STUTZKE: I think that's probably a function of the amorphous human, maybe a function of the amorphous sort of human error probabilities.

MEMBER CORRADINI: Well, can you repeat it please?

MR. STUTZKE: Okay, what I'm saying is the definition of a significant sequence per the PRA standard says any sequence that is one percent of the total or that when summed up contributes to 95 percent. So here I've got some 45 plant damage states that contribute 95 percent of the total.

MEMBER CORRADINI: Oh, when you add them up.

MR. STUTZKE: When I add them up, but yet individually they're down to 0.2 percent. And normally I wouldn't worry about what you hope in this type of analysis is that you only get a handful up at the top of the list.

MEMBER CORRADINI: Yes.

MR. STUTZKE: And this is flat, and it's created all kinds of problems propagating up through the accident progression of entry.

MEMBER STETKAR: As you said, this is population average. So you ran your model for each of the sites, because obviously the seismic hazard is somewhat different.

MR. STUTZKE: Correct.

MEMBER BLEY: But the seismic capacities were assumed --

(Simultaneous speaking)

MEMBER STETKAR: But the hazards really are not that much dramatically different. They're different.

MEMBER BLEY: They're not.

MEMBER STETKAR: But if I look at the HCLF capacities, you know, they're all in bins like 14 to 16. You know, so there are some plant to plant variability in the seismic stuff, but not really dramatic. Except for Columbia. Colombia is sort of, that's different.

MR. STUTZKE: Let's talk a little bit about the APET like this. In order to model the set of alternatives, different strategies, there are four different APETs developed.

The strategies are loosely characterized by the location of the post accident injection, whether it's an injection directly into the reactor vessel or injection into the dry well. Okay, in other words, so there's a strategy that says I have core damage, let's flood the dry well right now and abandon all efforts to try to inject into the reactor like this.

And that has a consequence because it means there's no potential or possibility of an in vessel retention if it's a dry well flood. You're trying to shore up your last line of defense, if you will.

There are also containment venting strategies, whether it is a wet well first vent or a dry well first venting strategy. Superimposed on top of that, these venting strategies could be characterized as open and leave open, or vent cycling strategy in an effort to try to retain more material inside the dry well itself.

It does have implications for the operator actions. An open and leave open is much easier than something where the guy's got to manually open it and close it all the time, like that.

Again, the consideration, we feed back the status of DC power because it effects the post accident SRV operation and potentially the post accident vent operation like this.

The same set of preliminary estimates on these things like that. The thing you need to realize is all APETs are supposed to do that the branch point probabilities depend on these specific PDS that goes in like this. And I've tried to account for that in the logic. It seems to work reasonably well.

That's 72 sequences of course coming out of the tree like that. Do you want to actually see an APET at this time?

MEMBER STETKAR: I'll be brutally honest, I didn't get to the APETs. I only had one question --

(Simultaneous speaking)

MEMBER STETKAR: No, I had only one question, and that is the DC power recovery. And you can tell how far I got because that's the first top event. That is modeled, it's either not there if it failed, it's failed if DC power failed early. So the seismic failures of DC power are taken care of.

If DC power fails late in the early part of the model, the value of that top event is 0.3. So it's obviously a human action, a local human action to restore DC power.

MR. STUTZKE: Right.

MEMBER STETKAR: If DC, if that DC is success, all of the subsequent human actions are modeled in the main control room. So functionally, that means that I got back all of the DC power that I needed to give me all of the indications and all of the controls that I need to do anything that needs to be done from the main control room, which strikes me as being quite a bit of DC power.

That's the way it's modeled, though. It's like all DC power is back to make life in the control room as normal because .1 human error probabilities are used on the success path, .3 human error probabilities are used on the failure path, which accounts for local stuff.

So is the actual success criterion for that top event getting all the DC power back that I need such that life in the control room is just as normal as it was?

MR. STUTZKE: That's my understanding, but I'll let industry or maybe Eric.

MR. AMWAY: Good morning, My name's Phil Amway, Exelon Corporation. The way, generally, we prioritize our DC power restorations is we'll supply a portable diesel generator to supply a battery charger, which then supplies the critical DC loads, which would be your instrumentation, communications, lighting, that type of thing, SOVs for SRV control.

So it is a reasonable expectation that if we were successful in re-energizing that battery charger, that we would get the DC power we needed to execute for the control room.

MEMBER STETKAR: Okay, but out here in the accident progression event tree, that didn't work because that was evaluated in the earlier part of the model and that's why we got a late DC failure.

So that didn't work. Now how am I getting enough DC power back? Is this another portable generator? And where did it come from, and when did it get there?

MR. STUTZKE: Wait, hold on.

MEMBER STETKAR: We already asked in the early part of the model whether or not I could maintain DC power after the batteries would normally be drained. And that's evaluated as operators hooking up a portable generator.

And the only way I can get to late DC failure, which is where, he's eventually going to get there. I thought you were going to the core damage event tree.

MR. STUTZKE: No, nothing up there APET because there's credit for a post core damage DC power recovery.

MEMBER STETKAR: That's the one that I'm asking about right now.

MEMBER BLEY: But it's asked once in the plant damage.

MEMBER STETKAR: Yes. And it's failed here. It's failed.

(Simultaneous speaking)

MEMBER STETKAR: Right. I can either get an early loss of DC power, which basically comes from fault practical purposes seismic. It's failures of DC power in the first four hours.

So it's battery fails during four hours or seismic lacks. If it doesn't fail early, it can fail late where late is defined as I don't have DC power after the battery life, let's say.

And to get DC power after the battery life, the core damage event tree says I need to connect the portable diesel generator and re-energize the battery chargers, as we've just described.

If that works, I don't have a failure of DC power. I transition on a plant damage state that says DC power's okay, and I don't really, the failure probability of DCCR is set to zero because I now have DC power forever. So essentially, DCCR is bypassed.

I only worry about really quantifying DCCR if I have failure of DC power late, which means either I didn't connect it, or I tried to connect it and the portable generator didn't work. And that's defined in a plant damage state as a late DC power failure.

That comes into this model and says under those conditions, a failure probability for DCCR is now 0.3, which is some local operator action. On the success path it's modeled as if all DC power is available in the control room because any of the other human errors that are evaluated on a success path from DCCR apply for normal in main control room human actions. Now, I got to point one number, but.

So the question is now what DC power am I getting back at a 70 percent success likelihood in this part of the model when I didn't get back the stuff that you're always saying. It took credit for that --

(Simultaneous speaking)

MEMBER BLEY: That's related to why it failed back in the plant event tree. But since they're separate event trees, I don't know how they're --

(Simultaneous speaking)

MEMBER STETKAR: -- human dependencies, I mean --

MEMBER BLEY: But they're human. I mean --

MALE PARTICIPANT: The question is are they linked.

MEMBER STETKAR: They're not linked. Well, they're linked through the end state that just says LT. LT means late failure of DC power. That could have occurred because either I didn't do what I was supposed to do, or I did what I was supposed to do and the equipment didn't work. I can get to LT either way.

That is not distinguished.

MEMBER BLEY: Then how does it work --

MEMBER STETKAR: Right, how is it working here?

MEMBER BLEY: And if it's people, why didn't it work the first time?

MEMBER STETKAR: And why did that certainly get equally smart now?

MEMBER BLEY: Or were you just delayed the first time? So there's a lot of complications that could be in the model, but --

(Simultaneous speaking)

MEMBER STETKAR: If this is a bunch of car batteries with jumper cables, which has been tried, it might get back the critical instrumentation and displays and controls that I need for the bare minimum things that I need to do. But that's not what the model says. The model says all the DC comes back.

MEMBER BLEY: Everything.

MEMBER STETKAR: Everything comes back.

MEMBER BLEY: Everything you need.

MEMBER STETKAR: There's no additional stress on the operators. It's as if the lights stayed on at time T0.

MR. AMWAY: If I could, you know, just try to at least address the question, because I realize there's other possibilities. You know, the generator you try to connect may fail. The FLEX strategies does include a provision for N+1, so there should be an available additional on site portable diesel generator that could be used for that case.

For the National Safer Response centers, they also provide backup equipment. So if the generator you had on site worked for X period of time and then failed, when you request that equipment for the National Safety Response Centers, that backup equipment would be provided that you could change out the generator.

There's also other methods to re-energize things such as the solenoid valves for the safety relief valves using B5B equipment, there are portable power packs that can be connected.

MEMBER STETKAR: But okay, let's talk about the portable power packs. That's not the same as me sitting in the control room with all the lights on and all my indicators going, and all of the push buttons that I have available all working.

That's hooking up now a car battery so that

I can go push a button locally and get that valve open because I know that today under this particular sequence I must open that valve. The model says I'm sitting in the control room and everything is available.

Now if you're accounting for this is FedEx airlift, okay. But why am I, you know, I don't know the timing of this. I didn't trace all of the sequences through here. I don't know why it's 70 percent, you know, reliable.

The only part of the model should have taken care of any hardware that you have on the site, so I'm not going to talk about well, they could go scrounge up the other generator that they have available, especially if it's N+1 and I have a multi unit site that are getting into trouble.

The main question is what are the functional success criteria for -- I'm not going to argue about the .3 number. That's a throw away. What's the functional success criteria given how you got here.

MR. STUTZKE: Right. Because basically we're talking about vent control, SRV control.

MEMBER STETKAR: Right. Yes. But I mean, if it's only vent control, SRV control, and indication for those things, I can buy this notion of a car battery because that's a fairly small amount of DC power. But the operators now had better not be confused about any of the other stuff that's black.

MR. STUTZKE: No, I understand.

MEMBER STETKAR: You know, and on that success path, they're 90 percent successful.

MALE PARTICIPANT: I think we're getting off track.

MR. STUTZKE: Okay, I think in order to wrap this up by noon, with your concurrence, I'd like to start talking about the preliminary risk evaluation of the alternatives on Slide 12.

We've made estimates of the release sequence frequencies for all of the analysis alternatives. There's some 20 current alternatives in the matrix, different ways to go about this. Noting that at this level of logic, some of these alternatives differ only because of the impact of the filter. So do you have a small filter or a large filter or no filter, like that. But the sequence logic is the same, and therefore the results are the way they are at this point in time.

In addition, I had mentioned before there are distinctions among the alternatives between an open and leave open sort of venting strategy versus a vent cycling strategy, a severe accident water addition strategy, which says turn on the FLEX pump and let it rip versus a severe accident water management strategy that says try to control the flow rate of flex pump to preclude or we'll say minimize the possibility that you flood the dry well and then have to shift over to the wet well vent.

But at this level of analysis, because we're only using the preliminary HEP values, you don't see any difference in the sequence frequencies as a result of that, so forth.

To try to remind you, the nomenclature is a little, no it's a lot confusing. And it's changed several times in there. This alternative three alpha is the post accident RPV injection mode and the three bravo is the post accident dry well flood scenario like that.

So I tried to give you an idea of a break down. One of the things I'm attempting to do here is to deviate a little bit from typical PRA practice. Normally we talk about what's the containment failure mode. If you go look at NUREG 1150 and they'll say oh, well the containment's vented or there's a liner melt through, et cetera, et cetera.

And the reality is you can have multiple containment failure modes that occur sequentially or simultaneously. So you could have an over pressurization failure followed sometime later by a liner melt through type. And so I tried to break those up.

When I say core debris, you'll see I'm talking about liner melt through, you know, versus retention inside the dry well versus retention inside the reactor. But those are separate. I'll show you another view graph about over pressurization types of modes like that.

MEMBER CORRADINI: And so to read this table, I was trying to understand, but you're going to explain it to us.

MR. STUTZKE: I'll try to explain this. So these give you the indication of the source of post core damage injection. One is our base case model, et cetera, et cetera. We have cases here of wet well versus venting where that venting is a manual in the pre core damage and it's a manual operation post core damage.

MEMBER CORRADINI: So may I ask just a question with the big black one, number one? So is there a well on the floor of the dry wall under one?

MR. STUTZKE: No. This is the base case which gives no credit for any post accident injection of any kind.

MEMBER CORRADINI: So there's no sprays, there's no leakage, it's as dry as a bone?

MR. STUTZKE: Yes.

MEMBER CORRADINI: Okay.

MR. STUTZKE: So yes.

MEMBER CORRADINI: And that's considered realistic why? I mean, I'm sure from the uncertainty world of Mr. Stetkar there's always somewhere in some tale that it's dry as a bone. But I would expect there's water. So can you --

(Simultaneous speaking)

MR. STUTZKE: Well when I say water or not, I mean there is no deliberate attempt. This is the base line --

(Simultaneous speaking)

MEMBER CORRADINI: Okay, there's no deliberate attempt?

MR. STUTZKE: No deliberate attempt.

(Simultaneous speaking)

MEMBER CORRADINI: There may be an accidental spillage, but there's no --

MR. STUTZKE: Yes, sure. You know, the MELCOR will pick all that up.

MALE PARTICIPANT: You mean there'll be seal leakages and things like this?

DR. ESMAILI: Yes, this is Hossein Esmaili. Yes, the MELCOR calculation makes the assumption, and the industry calculation we assume a linkage of 36 GMP. So by the time the lower head fails, there is a, you know, about one to two feet of water.

MALE PARTICIPANT: But that makes no --

(Simultaneous speaking)

DR. ESMAILI: If you have one injection at some point, that water is boiled away and it leads to liner melt.

MEMBER CORRADINI: Okay. I'll come back --

DR. ESMAILI: Even at three days.

MEMBER CORRADINI: I'll come back to that.

MR. STUTZKE: Okay, one of the cases here we discovered yesterday may not be applicable anymore, and that's the one here on the right. The idea here was that we were proposing a strategy that said put passive rupture disk into the vent line.

So eliminate the operator action, and it will burst whenever it wants to burst like this, and flood directly to the dry well. So it's kind of like a, you know, fall back or almost a failsafe type of strategy like this.

The difficulty with that is that you can't have a passive type of vent pre-core damage and have any sort of anticipatory containment venting to extend your RCIC pump operation. So it, how to say it?

MEMBER STETKAR: Well, you know, if you put a block valve in front of it, you can. But then it's not quite as passive --

(Simultaneous speaking)

MR. STUTZKE: Yes, so I guess to say it's boolean logically correct, but it's not logically correct. So I'm thinking about just discarding this as an option. We discovered it yesterday, and it's like, doesn't really make sense.

But you can see, there's distinguishing between manual venting and operator controlled venting evolution pre core damage versus post core damage for maybe you would want a passive rupture disk come in, you don't see a great deal of change. The number's actually different, but it doesn't help too much.

Again, that's a reflection of the HRA values that are in there right now. Some of this is not so much to key in on what the answer is, but to decide whether you like the format of the presentation of the results.

Is it telling you something useful or not, or should I draw some different charts like that? Again, these are the status of the containment venting situations where when I say over pressurization failure means none of the vents are open and you're actually lifting the dome on the dry well at about 80 pounds, I think, is the assumption here.

Cases where all the venting is going to the wet well or cases where the venting is going to the dry well vent, and hence could not be scrubbed by the suppression pool like that.

Let's see. So I told you earlier in the presentation, you know, we're looking at ways to assess and reflect on the results through a series of sensitivity analyses. I gather from your comments earlier you're looking forward to a full blown Monte Carlo uncertainty barometric propagation. I'll have to think whether I can get that done by September the 15th.

MEMBER STETKAR: I get upset by people, when question in a forum like this we say well, we're considering all of those uncertainties in the PRA models when they haven't yet been considered. How and when we're going to do that is --

MR. STUTZKE: Yes, I understand. You know, and then they say an effort of this is worth doing. I mean, it's interesting, but the level of it. What we're thinking about now is to focus on contributions from operator actions.

And the reason is there's been some concern about human reliability. You heard there was a commission meeting sponsored by former Commissioner Apostolakis where these issues came up. We went to brief Commissioner Ostendorff separately on credits for human reliability work in the context of this rule making.

And his attitude, or I guess expression was, you know, people need to train, we need to have enough people on site, et cetera, et cetera. And I can appreciate that. I mean, former Navy as the Commissioner as myself.

But that doesn't remove or alleviate the problem I have of trying to actually estimate the HEP, which is part of the quantification of the benefit. You know, I can't hide behind it. Somehow we have to be able to do it.

So one of the sensitivities that I've done here is to set all of the HEPs to zero. The idea then is to look at the contribution only due to the hardware. And when I do it, what I see is, in terms of the conditional core damage probability, it does go down, but it's somewhere between 15 and say 30 percent depending on which site you want to pick.

And that's a reflection then of, you know, the flex hardware reliability itself, the SRV hardware, et cetera, et cetera, as well as all the seismic failures that may actually be too low like this. So it's kind of interesting what I think is driving the answer to this is that RCIC pump failure short term.

MEMBER STETKAR: Marty, the only thing that I, if indeed the seismic stuff changes dramatically, then displaying, as I said, I don't think we're going to have a discussion about human reliability analysis later, so I don't want to dwell too much on that.

But if the seismic, the seismic contributions are already measurable. If they become much more important, I mean, what you're doing is you're just multiplying mean fragility by mean hazard right now. And we know that there are substantial uncertainties. If the uncertainties in the fragilities are modest but measurable, the uncertainties in the hazard are really, really large.

So understanding the shape of that contribution, if it's, even now, when it's certainly a visible fraction of what you're showing here, the shapes of those distributions and the amount of uncertainty, you know, where that mean hazard is in relation to the full set of hazard curves could be useful information.

MR. STUTZKE: Well, to be a little candid, when we started this, all we had were the results from generic issue 199, those hazard curves. And at the time, USGS hasn't issued any uncertainty fractals at all. Now with the recommendation 2.1 submittals, there's a full set of uncertainty curves to those. And so it is possible to propagate it through.

MEMBER STETKAR: You talked to USGS by the way? Who talks, who else talks to you? Tell them to extend their 2014, even their PGA estimates, don't make it 0 after 10^{-6} because that's a big drop.

MR. STUTZKE: Yes, I'll --

MEMBER STETKAR: I went back and compared your hazard curves against the 2008, I know where you got your hazard from.

MR. STUTZKE: Yes.

MEMBER STETKAR: And then I compared them against the 2014, and that's when I discovered the zeros. So now you do actually have the fractals, right?

MR. STUTZKE: Yes, the licensees were obliged to provide those and we have them to work with.

CHAIRMAN SCHULTZ: And that treatment can provide, given what we talked about earlier with regard to seismic impact here, and perhaps a re-analysis, the treatment of those uncertainties could have quite a dominant impact with regard to overall uncertainty evaluation.

MEMBER STETKAR: I mean, you know, it won't affect these mean values. But the display of where you are entails of the uncertainty distributions to drive these new values. Especially in the seismic part.

MR. STUTZKE: Yes.

MEMBER STETKAR: Is I think important information for someone.

MEMBER BLEY: Now, just to get a grip on what your little sensitivity study here is telling me, anywhere when using FLEX equipment, you got to take it out and hook it up, so that's an outside of the control room action. So everywhere FLEX is coming into the picture, we've got a .3 failure probability from people.

MR. STUTZKE: Right, from those types of actions, yes.

MEMBER BLEY: Yes. For this kind of thing. So overall, FLEX and the other modeling we're doing here is getting us a factor of two. And core damage frequency, it's basically what's there, which is --

MR. STUTZKE: Yes, that's the implication. Yes.

MEMBER BLEY: Yes. Which is what you modeled, so that's where it has to come out. Yes. I'm sorry, Mike.

MEMBER CORRADINI: Well, I wanted to actually, just to clarify something Marty said maybe in between John's interrogation, discussion, is that you said something about RCIC that I wanted to, and my interpretation is the key thing is between the time, unless I misunderstand what you said, between the time that you need to bring on external assistance and the time things are starting to degrade significantly, RCIC operation is crucial.

MR. STUTZKE: Yes.

MEMBER CORRADINI: RCIC operation with DC power, or RCIC operation without?

MR. STUTZKE: Doesn't matter. Both. I mean, the assumption, remember, Phase 1 is reliance in end point systems, and for the BWR Mark 1 that is the RCIC pump.

MEMBER CORRADINI: So how is, maybe that wasn't the right one to ask. So somewhere today somebody is going to explain to us how they model RCIC without DC power?

MEMBER STETKAR: Yes, I was going to, just to help you, Marty spoke a little quick, there is a human error probability associated with local no-DC operation of RCIC. So they account, it's .3 like every other local action, but they presume that the operator can do it locally with a 70 percent likelihood of succeeding. But that's just the nominal .3 that they throw in for any.

MEMBER CORRADINI: I guess I wanted to explore that a little later, whenever, if we ever --

MEMBER STETKAR: So they do toggle, I mean, the same hardware applies. It's just is it only hardware started and running automatically, or is it hardware plus this .3?

MR. STUTZKE: Yes, and this sensitivity says we assume they can do it, so it's just down to the hardware. The pump has to start types of things.

MEMBER CORRADINI: Thank you.

MR. STUTZKE: Okay. But we will do other types of sensitivity analysis like this where we need to vary the individual human failure events to try to get a feel for what's driving the answer.

You'll notice, I mean, one of the, the logic model is actually constructed in Microsoft Excel, not one of our full blown PRA worksheets, and that's because SAPHIRE doesn't quantify the seismic events, in my mind, appropriately. It doesn't do a good job on the success paths.

MALE PARTICIPANT: See, if they hidden it in SAPHIRE, I couldn't have figured out what was going on.

MR. STUTZKE: Like that. And the result

of it is it has limited, you know, it's limited by my ability to do, I can't just say gee, give me all the importance measures and tell me what's going on. It requires a little digging around to figure out what's driving this sort of thing.

So you know, the intent, I would love to be able to generate all those things, and again, it's what can I do between now and September 15th with the purpose of understanding what the model's telling me, whether it's correct or not or some sorts of insights like that.

So I guess to finish this up, you know, we're waiting to complete the human reliability work, and once I get it, I will put it into the model as well as the rest of your comments, and we'll get the internal review and all this sort of thing.

It's my understanding the max runs have basically been completed by this time. So we're ready to multiply those times the release category and finish up the inputs that Aaron needs to complete the right analysis.

MEMBER BLEY: Well, we'll see the human analysis stuff later today. But the kind of thing John brought up about how the DC is linked between the front entry and the back entry are questions I would have thought they would have been bugging the hell out of you about how am I going to do this human reliability analysis, I've got to understand what's going on here in the plant.

I get the sense that probably hasn't been, not at that level right now.

MR. STUTZKE: We're just starting that. You know, I guess the way to characterize it is nobody on this project team is bashful. Okay, and we're now just getting into this, you know, people showing up in your office and what's going on.

So you know, to put it that way, we have a very good relationship between the MELCOR and the HRA and whatever, but we're just now getting down to the brass tacks.

And part of it is because the alternatives have modified. You know, they keep morphing as we analyze and we meet with industry and they have a few more alternatives, you know, and we're obliged to go after those and things.

MEMBER BLEY: My fear, and we'll see this later, is in the four weeks that we know between now and the middle of September, there's not enough time to hash all this kind of stuff out in a way that will give me confidence in whatever comes out of that piece of the analysis.

MR. STUTZKE: I slept last month.

(Simultaneous speaking)

MR. STUTZKE: It is, it's problem to get it done according to the schedule like this. And it's not just the interplay between the HRA and the PRA and things like that, you know. I can just imagine the reaction if I have to ask for more MELCOR runs. Oh, I forgot this scenario, guys.

I think we're covered. You know, and that propagates into the max runs, as well. You know, I think we're covered because we've done a large amount if interaction with the industry, and they have thousands of map runs. We've done map runs ourselves. Thanks. But there's always that possibility to bring this thing to our close.

MEMBER BLEY: In the interim between a draft reg basis and a final reg basis, is it anticipated you're going to have to do a lot of revamping of the model, or are you thinking that you can live with the model and you're going to be arguing about the rest of the problem?

MR. STUTZKE: I think we can live with the model. I mean, there are other issues, you know, how to establish appropriate low level performance criteria and things like that that go on beyond what the technical details of the risk calculation are. We'll see. That's all I have for you.

MR. SZABO: MELCOR?

CHAIRMAN SCHULTZ: Yes, we'll move on now. MELCOR, if you want to.

MR. BASU: We'll move right onto that, thank you.

(Off microphone comments)

MR. BASU: Okay. My name is Sud Basu. With me is Dr. Hossein Esmaili. We're going to give you a rundown on MELCOR, with regard to the scope of MELCOR analysis, where we are, and how we are using MELCOR in the overall scheme of that wall diagram that Aaron showed earlier.

And I'm going to go through the first few slides and generalities, and then Hossein will pick up with MELCOR matrices for Mark 1 and Mark 2 and will show you some results.

Okay, so this question on here today, how the work that we're doing now is informed by past work and other published information. So I just want to mention that the MELCOR analysis that we are doing, first of all is consistent with the SECY-12-0157 work that we have done which are based on, which is informed by SOARCA.

And then you can go back, and I'm not sure whether, you know, NUREG 1150 is the only reference at this quantity that this reference was mentioned. But we are certainly informed by the past work on SOARCA, SOARCA uncertainty, and 12-0157, and there are some other work that informed the work that we are currently doing.

It is also consistent with the 12-0157 approach. We didn't do anything new in terms of significantly or drastically different from what we had done in 12-0157. It does covers alternatives and options considered, long term developmental analysis, as well as the PRA discussion that you had just now.

There was also a question earlier about, it was in the context of schedule, but I think the other aspect of the question was how we are receiving in these activity with regard to external stakeholder participation.

And I'll tell you that the analysis that we have done and that we are going to present is data information exchange between industry and those meetings between the industry and NRC. The assumptions that we have and which I'll go through shortly are consistently those of industry, and it is upon the PRA and SRA and so HRA.

There are some differences between staff's PRA, HRA, and this industry's PRA that you're going to see later on. But the differences really matter in terms of the MELCOR analysis, unless Marty comes back few months, six months from now and tells me that I have missed a significant dominant sequence and I need to narrow out another ten MELCOR.

So I think you heard Marty is pretty confident that it's all covered. For these general assumptions in MELCOR that we have, it's all transient stuff with extended loss of AC power.

And the transients are 72 r's in duration. We assume that the order in EA-13-109, that the vent order that is in place. Likewise, we assumed the EPG/SAG Rev 3 that the industry's SAG is in place, as is FLEX.

It is assumed in place, but pre and post core damage, with FLEX will vary between pre core damage and post core damage.

MEMBER BLEY: Let me ask you a question.

MR. BASU: Yes.

MEMBER BLEY: Because I don't know the crux of how the code works. When you had to add these actions later in the accident that the FLEX provides, did that end up meaning you had to actually change the code, or is it just a way to provide inputs that you would have -- you usually let the thing run through the accident, but now you're interfering in it along the way.

MR. BASU: So part of the answer is in the next bullet, mitigation of various R model in the code. And as for the timing the issue is that that must have the input, too.

MEMBER BLEY: And that capability was already there.

MR. BASU: Yes.

MEMBER BLEY: You didn't have to rewrite the code to take care of it.

MR. BASU: No.

MEMBER BLEY: Okay.

MR. BASU: I mean, we had to actually put in the model for mitigation that was, we have it in

12-0157 as well, except that there we did the scope of studies because the mitigation --

(Simultaneous speaking)

MR. BASU: They were not as formalized at that point. In steps of more progression that Marty discussed, all of them, with the exception of, I think Marty had retention that is really of interest, and you can imagine there's coming up to what things and then see what happens, right? So the accident has to happen, so special vessel has to breach. So in vessel retention is not one of the possible end states.

So likewise, in containment, I think he mentions in containment retention, that's not possible end state. But the other end states are mentioned liner melt, which is a bypass accident, a mainstream line creep rupture, the HEP flange leakage, and over temperature or pressure failure of the containment. Next one.

So this was a question, how we do it. RCIC operations and that's mitigated. Measure, we model it, and Hossein is going to go through some of the details, so I just want to go quickly over.

But the message here is that mitigation measures are modeled, RCIC operation, we read pressure control in the next couple of slides, containment venting, and it includes vent control at different pressure rates and all that, side vents slightly as well. Next one.

And then the RTV injection as well as dry well injection with sensitivities, and also switch over pump as it regards to dry well. Okay. So that bring us to various options that we have. Usually in the MELCOR analysis, we include it in the MELCOR analysis.

And if we didn't confuse you sufficiently in the morning session on various regulatory options, I'll tell you that this is here another variations of what you had seen in Aaron's slide as well as in Marty's slide.

And I mean, I can go on explaining how this maps to there, the other two slides. But the important message here is again that if you pick up what are the real options? The real options are venting and water addition of some sort of water management.

And any combination that you can think of are really covered in all of these options in one or the other, options are the sensitivities that we have performed.

So in that sense, we do cover the

inevitability options that are presented. And please don't be confused at this point with, you know, three alpha or four bravo or four Charlie three.

MALE PARTICIPANT: So they don't align, but the words align?

MR. BASU: Right, exactly. So let's see. The next slide, please. So one of the things that come out of MELCOR, this would be dry well structure temperature for example, or wet well water temperature. And these are just examples I'm giving. The hydrogen and non-condensable generation.

And we are tracking this because these can be related to some sort of performance measures, containment performance. Is the containment then special, is there over pressure protection, is there over pressure failure, is there over temperature failure. Is there hydrogen concentration, for example, in the vent line that would constitute some risk?

Is the wet well suppression temperature high enough that it is going to beat on the RCIC operation, or it is going to maybe scrubbing, much less the friction. So those are the things that we are looking at, and those are the reasons we're tracking these barometrics.

And then there's these other class which is source term, which provides the input to max. And of course, MELCOR does provide not just cesium and argon but two classes, there are other classes. And all of these go to max.

And for the purpose of MELCOR, we normally show cesium risk reaction because that has implication on latent cancer rates and also land contamination. And we show argon because it has impact on fatalities and operator dose.

So with that, I'm going to turn it over to Hossein who's going to walk you over the MELCOR analysis for Mark 1 and Mark 2, and some example results.

CHAIRMAN SCHULTZ: In terms of the source term, it says you have displays of cesium and iodine, and those are representative, or for purposes of describing the output --

MR. BASU: Yes.

CHAIRMAN SCHULTZ: -- in the source term area.

MEMBER REMPE: So, I'm sorry, are you done?

CHAIRMAN SCHULTZ: Go ahead.

MEMBER REMPE: Okay. In the write up we

received, you talked about some of the key parameters that were identified from the SOARCA evaluations. And when I look at those parameters, I would think that there's quite a bit of uncertainty in some of them at this stage of our knowledge with EWR specific to the accident progression.

What will you be doing to try and address those uncertainties in this evaluation, because if you're making decisions about filtering, it seems like you would want to have a grasp on that.

MR. BASU: Well, since my response is going to be scribed, that in the humanistic world, we don't talk about uncertainty. We talk about sensitivity.

MEMBER REMPE: So you're just going to do sensitivity analysis?

MR. BASU: Well, now the point is, no seriously, the point is we have done SOARCA uncertainties. And that's a huge effort that we expended. We are still in the midst of it.

We can go through that in this, except that it is going to throw the schedule off. Whatever. So I think when we look at the range output parameters that are there, you know their signatures, the cesium release for example, in the number of cases that we consider this for, and you see that they are kind of pretty, you know, I mean, I hate to use the term bounded.

But I mean, the range that you see, and then if you impose a level of uncertainty there, the range that you're going to get will still be something that's not going to cause a severe alert in terms of their consequences, if you will.

MEMBER REMPE: Okay, so --

(Simultaneous speaking)

MR. BASU: What I'm saying is instead of do this full blown uncertainty analysis, we are looking at some sensitivities.

MEMBER REMPE: Okay. Again, the write up is only 17 pages. So perhaps when the full document comes, we'll have a better grasp on it. But in the, I don't know, eight parameters that are listed here on Page 17, did you go through and do minimum and maximum values for these parameters, like --

MR. BASU: Okay --

MEMBER REMPE: -- clad drainage rates, Zircaloy melt breakout temperatures --

DR. ESMAILI: If your question is our understanding of melt progression of BWR right now, we are just relying on what we know. So we are relying on the state of knowledge. Perhaps, you know, after Fukushima, once we open it up, if we know a little bit more, then we can refine. So that we are not going to address as part of this analysis.

But what I can tell you is that what is in MELCOR does not make a distinction between PWR and BWR. The models are equally applicable to BWR and PWR in terms of, you know, what happens to the cladding, what happens to the canister, what happens to other structures. And we are not doing uncertainty analysis as part of this set.

MEMBER REMPE: Okay, again, I appreciate the comments about that we still don't know until we open up the reactors because I think that's an important comment. But what I'm hearing is we're going to do sensitivity studies, and there are some key parameters identified from the SOARCA analyses, and are you going through and doing sensitivities for those parameters is the only question I'm asking.

DR. ESMAILI: So the two parameters that you just mentioned, those are being looked at under the SOARCA uncertainty analysis. So we're going to be informed by what they find as the effect of those parameters and the uncertainties in those parameters to the overall result.

MEMBER REMPE: So they see the causes of factor of ten and the results will multiply your results by a factor of ten? I mean, this is something that's like a fundamental input to your code or something.

MR. BASU: I'll tell you what, if it is only a factor of ten in the release fraction, I'll be very happy because that's the level of uncertainty that we're willing to live with in a factor of ten.

We know that their models are not perfect. We know that there's that uncertainty, and we have always considered that in terms of the release fractions, if there's a factor of ten, then we do pretty good.

MEMBER REMPE: But that's one input parameter, and then there's, like, seven others. And so what -- it's going to definitely increase.

MR. BASU: So unfortunately, I don't have that piece of paper with me. But I think the parameters that you're looking at, many of these have been addressed under the uncertainty, SOARCA uncertainty analysis.

So we're going to be informed by that. There may be one or two parameters there, there may be parameters on the ex-vessel coolability. They are not currently being addressed by SOARCA uncertainty explicitly.

However, we are now actually implementing in both collaborative models in the MELCOR, and industry can speak to what they're doing in terms of --

MEMBER CORRADINI: I was going to say, I was expecting to tell Joy that the uncertainty in certain things will be described because there's a different approach by the industry about this, and you might see an effect simply because a different set of modelers have done it. That's what I was --

MR. BASU: Yes, we'll actually lever those things in the report that we are preparing, yes. So when we implement these models into MELCOR, you are going to see some implemented in the coolability model for example, or you would see some effect on the results.

At this point, we don't expect to see that it is going to change the, not the consequence, the release structure results, so much that we're suddenly going to have a two orders of magnitude, for example, the effect. I don't expect that.

DR. ESMAILI: And you know, again, uncertainty narrows it's focus on one sequence, long term station blackout. We are focusing on different sequences. So some of these uncertainties are going to be captured with sequence to sequence variations.

SOARCA was a long term station blackout. Here we also have a different sequence. We have, as we pointed out just before the break that we have re-circulation line leakage. That by itself is going to change the float inside the RPV that releases, et cetera.

So you know, the sequence to sequence variations, in addition to model parameters, are going to change our release. So we are just focusing on more sequence to sequence variation as part of this effort. And assumes that we are going to rely on whatever we learn from SOARCA analysis that you say that yes, things can change maybe by a factor of five, by a factor of ten, by an order of magnitude.

But as you get to high releases, you are not expecting things to go to 100 percent. So that range of uncertainty, I expect it to be higher as the releases are going to get higher and higher. There's a limit to, you know, how these uncertainties can propagate.

MR. BASU: So I'll make one more statement and then I'll shut up. So with all the norm modeling differences between industry severe accident code and our severe accident, staff's severe accident code, you'll see that in the thermal hydraulics domain, we are getting remarkably close results.

In the source term domain, we are seeing some differences. And we are looking into it as to why, you know, why it is what it is kind of thing. And we'll report back to you.

MEMBER REMPE: Thank you.

CHAIRMAN SCHULTZ: Can you characterize the significance of the difference at this point? I mean, it's enough so that you want to work to resolve it.

MR. BASU: I think daily, the COD source term directly results and the rest of the presentation. And then he will have the opportunity, the industry's presentation. And maybe at that point we can have the dialogue.

CHAIRMAN SCHULTZ: Look for it later, then. Thank you.

DR. ESMAILI: Okay, so this is the smallest font size I could find.

(Simultaneous speaking)

DR. ESMAILI: But this is on purpose so you could not see exactly what we did.

(Off microphone comment)

DR. ESMAILI: But I don't want to go through all of these. You know, I'm just trying to highlight, Sud touched upon this in his earlier. We are considering the cases as these are option one, the cases with no water addition.

Then we are considering cases that you have water addition, but no management. Then you have cases where you have been cycling, et cetera. So overall, we ran about 41 sequences.

This was based on the, you know, to inform what the PRA was trying to do. So whether you see essential RP pressure control, there were some sequences that we had availability to do RPV pressure control. That doesn't mean that, you know, you are going to control the pressure for the three days.

At some point, it's going to fail and the containment, the RPV is going to fail, and the vessel is going to fail. So it doesn't, but I show that in some cases we looked at, you know, like, four hours pressure control so that we can go back to high pressure. So we are going to look at high pressure sequences.

Then in terms of RCIC availability, we have long term RCIC availability, short term RCIC availability. There are cases that we have, you know, no RCIC available from the start of the accident.

In terms of RCIC, Sud mentioned we have all the baseline calculations that we are doing, assuming the sections from the suppression pool. We have some cases that CSD is the source.

In terms of failure, at what point, you know, we had discussed this in earlier meetings with the industry back in December. We are going with the 230 F. We think that's a reasonable temperature, you know, for RCIC failure temperature.

We did one case when we extended it to 240, as you can see all the shaded regions. In terms of anticipatory venting --

MEMBER CORRADINI: Could you repeat the shaded region again, I'm sorry.

DR. ESMAILI: The shaded regions are trying to, you know, just to distinguish whether the main differences between some of the baselines. So for example, you know, in terms or RCIC, the base, or RPV pressure control, the baseline is that you always have power so you can always manipulate RPV pressure control.

There are some cases that we ran that said oh, you only have four hours, you know, such as a long term station blackout in SOARCA that you lose control and then it gets re-pressurized.

Then in terms of, so pre core damage, anticipatory venting, in all cases we assumed 15 psig. You know, but some of those cases are not relevant because what happens is that it turns out that in a lot of cases, we don't do anticipatory venting.

So in some of the cases, we're forced to do anticipatory venting at 15 psig. We have one case that we dropped it to about 5 psig so we know, you know, what the response should be.

Post core damage, we have injection at the time of lower head failure. So the question came how do you do that. You know, we have control function written. We know when the lower head failure occurred, at least in a calculation, so we know when to start injection.

MEMBER CORRADINI: Can I just make sure I get it? So numbers 45 through 50, you had no RPV pressure control?

DR. ESMAILI: It's going to be cycling.

MEMBER CORRADINI: It just does it itself?

DR. ESMAILI: Yes, there is no pressure point.

MEMBER CORRADINI: And you -- Where did it go? And two of those you have no RCIC operation so I --

DR. ESMAILI: That's right.

MEMBER CORRADINI: -- would assume 750 get the --

DR. ESMAILI: The short-term station blackout.

MEMBER CORRADINI: Conservative. I know I'm a bit conservative. Higher end releases.

DR. ESMAILI: Not necessarily.

MEMBER CORRADINI: No, no, no.

DR. ESMAILI: Not necessarily. Actually, you know, some of those cases, you know, you don't saturate the suppression pool. You are --

MEMBER CORRADINI: Oh, because you have FLEX, you actually have FLEX operation.

DR. ESMAILI: Well, you do have, but this is, FLEX operation is post-core damage. In order to justify my employment here I have to do calculations to actually go through core damage and vessel breach.

MEMBER CORRADINI: Okay. So I am wrong because there are some things under Cases 1 through 6 because of no, of dry, of no --

DR. ESMAILI: There is no injection.

MEMBER CORRADINI: From cases --

DR. ESMAILI: Option 1, which is 1 through 6, there is no injection. There is no injection at the time of lower head failure. Okay, so there is no FLEX.

MEMBER CORRADINI: Okay.

DR. ESMAILI: Okay?

MEMBER CORRADINI: Okay.

DR. ESMAILI: These are the cases that if you remember I said that even these cases, because we have some time that, you know, RCIC's operating, for at least about ten hours, and you do have a leak, you know, a pump leak, a leak that you do accumulate about between one to two feet of water in the pedestal. So in these cases the pedestal is not completely dry and that's what Marty was showing you.

But these cases, because we don't inject, at some point we are going to dry up and at some point, you know, well before three days, you are going to lead to the debris being mobile again, attacking the liner so we're going to get liner melt through. Even though you have some pre-existing water, it's not going to prevent liner melt through for you.

For all the cases that you do inject at the time of lower head failure, considering the fact that you have some pre-existing, you can prevent, if you have continuous injection, you can prevent liner melt through. This is consistent with past studies that showed as long as there is water, you know, you're going to prevent liner melt through.

MEMBER CORRADINI: Okay, thank you.

DR. ESMAILI: So in terms of post-core damage injection at the time of lower head failure either into the RPV or into the drywell, in terms of level control we either have no level control.

That means that at some point, this is Mark I, at some point you have to switch from the wetwell venting to the drywell venting because you're, you know, you're covering all the way up to the vent and we do consider cases where we are throttling the flow so that, you know, you don't have to do that. You never have to go to a wetwell venting post-core damage.

We actually ran some cases as SRV operation, allow SRV stuck open failure. It turns out that when you are doing pressure control, you know, your pressure is relatively low, 200 to 400, so in order for us to find out, you know, what are the consequences, for example, of a main steam line creep rupture, you actually need high pressures. It's very, very difficult to get a main steam line creep rupture at these low pressures.

So we actually disable this SRV. Assume that, you know, SRV does not fail but this is a low probability. Either it's going to fail because of thermal seizures or number of cycles.

All right, so we go to the Mark II run matrix. For the most part, the initial and boundary conditions are the same as the Mark I. Actually copied the same, just deleted some of the rows that had from Mark I.

The run matrix is condensed because of the insights we obtained from the Mark I. For example, we just looked at the representative cases where we saw that, you know, most of the variations could occur.

We didn't concern vent cycling cases for a number of reasons. Vent cycling cases, I will show it to you later. On a case-by-case, although it show some improvement but there are sequences where, you know, even if you don't do vent cycling, you know, your releases are almost the same and the fact that in the Mark II you have a bigger containment volume. So, you know, you can start injecting water into it without having to go to a drywell venting.

Oh, okay, that's the reason for the water management as a matter of fact. We didn't consider water management in this case. That means that we did not try to throttle the flow. We just let the water go all the way up to the, near the top of, you know, where the vacuum breakers are, sorry, where the vent line is because, again, you have much, you have 30 percent more volume and so any transition to a drywell venting, if it's needed it's going to happen much, much later in time.

We did look at sensitivity to containment design. What we have is that the base calculation that we had, because of the availability of model, we looked at it for a dry lower pedestal which is representative of LaSalle.

So there is no water below the pedestal. We thought that this, the fact that you have a dry lower pedestal and the fact that you are going to inject water at some point, reasonably bound the releases that you're going to find between no water and water injection.

But we did some scoping calculation using the existing model that we have. Look at the, you know, dry lower pedestal by just removing that and just filling that volume with water so we could look at, you know, if debris falls into the water what happens in terms of releases, et cetera.

Now, in terms of the relocation, in the Mark II you have the upper pedestal and the lower pedestal and most of the plants, actually all of them except one plant, they have drain lines that previous studies, NUREG-1150 said that as soon as you have relocation, short time later you're going to fail, this drain line it goes. You know, and NUREG-1150 estimated, like, in 20 minutes for LaSalle and then six minutes for Limerick.

So what we did is we did sensitivity calculation. We assumed that, you know, there are differences. You know, we assumed it's almost immediate. As soon as the debris comes in, it's going to go to the lower, to the wetwell.

And this would be so we were trying to formulate cases where you actually have downcomers like

Shoreham, for example, or Nine Mile Point I think. They have downcomers and they have what is called corium rings that, you know, they have sloped upper pedestal that would just pour the debris into the lower pedestal region. So we did these sensitivities, you know, just using the existing model so these are, you know, scoping calculations.

Okay, so now these are the results of all the 41 calculations for the Mark I. So I tried to label it. So if you have, Option 1 is no injection. You know, these are we think the highest releases because these are the cases that eventually either lead to a liner melt through or to the lifting of the upper head because of, you know, over temperature.

MEMBER CORRADINI: What do you assume for the temperature and pressure for lifting of the upper dry well then?

DR. ESMAILI: For the overpressure we assume same as SOARCA, about 85 psi, you know, that, you know, start to lift it.

MEMBER CORRADINI: So that gets back to what I was trying to --

DR. ESMAILI: But the thing is that in all the cases we are venting, we never get to that pressure.

MEMBER CORRADINI: I understand but I just wanted to make sure I -- I couldn't remember what the value was so thank you.

DR. ESMAILI: Right. And then for overtemperature, this is a discussion we actually had yesterday, is that as soon as the temperature hits 700 degrees Fahrenheit, we are opening, you know, we are assuming that there is a leak. A leak occurs at the drywell head. So this plus the liner melt were the two main failure mechanisms for the Mark I.

So what you see literally from this is that, you know, additional water, so when you go up, whether it's RPV injection or drywell injection, it's going to reduce the releases. As I was saying, there's a wide range, as you can see, from sequence to sequence, depending on what you actually do.

What we find out is that, you know, whether you are injecting into the RPV or into the drywell, in terms of releases, it's not going to change that much, the releases and --

MEMBER CORRADINI: Say that again, please.

DR. ESMAILI: Whether it's RPV injection or drywell injection, the releases are not going to be significantly affected.

MEMBER BROWN: So these are not a combination? It's not RPV and drywell. It's one or the other?

DR. ESMAILI: It's either, yes. So, for example, Option 2A, if you see here, Option 2A is RPV injection. Option 2A is just water addition. That means that you're going to start injecting.

MEMBER BROWN: And there's no vent cycle yet, right?

DR. ESMAILI: There is no vent cycling. Vent cycling is only 2B and 2C.

MEMBER REMPE: Is the timing the same on all these cases? When you say, well, the cumulative release of cesium is the same but is the timing not going to vary --

DR. ESMAILI: We just looked at 72 hours. We looked at 72 hours for how much cumulative, cumulative.

MEMBER REMPE: Did some of it come out early? For these cases a lot of times the timing of when it would come out would be different.

DR. ESMAILI: The timing could be different, right.

MR. BASU: The timing --

DR. ESMAILI: The time --

MR. BASU: Sorry. The timing of release would be different but then if you integrate over 72 hours, which is the period of interest, that's a better indicator of how much you are really releasing. Yes, I mean, you may be releasing in one case earlier than in the other case and that all depends on RCIC failure timing as well, so.

DR. ESMAILI: These releases are dominated by the venting. So I think, you know, once we are, we will give you more information when we do the write-up.

But in almost all cases we're talking about 72 hours but you require venting at about maybe 14/16 hours because, you know, you have gone to core damage. You have produced enough hydrogen that, you know, whether it's going to be PCPL or PSV you're hitting your third, your 60 psig and you have to vent. So this venting occurs early.

In the case of a Mark I, actually this venting occurred even before lower head failure. So in some of the cases if you see like that, you know, the base case that I showed you in Case 1, lower head occurs, you know, in about a day but the venting occurs in about 14/15 hours so that's a difference.

MEMBER CORRADINI: Eventually you're going to get to the arrows, right?

DR. ESMAILI: The arrows are going to be the cases where you have main steam line creep rupture. I told you these are low probability events because we actually had to disable SRV cycling, SRV thermal seizure to get from main C.

MEMBER CORRADINI: So if I might ask, the red square under 3A, since that, something that Joy had said, you know, if I give it an order, I'm happy but that's a factor of five. What's going on with the red square under 3A that makes it five times larger than, twice as large as 1 and five times larger than 2A? I'm struggling.

MR. BASU: Okay, so 2A red square. Are you talking about 2A?

MEMBER CORRADINI: 3A red square.

MALE PARTICIPANT: 3A red square.

MR. BASU: 3A red square is the main steam line.

MEMBER CORRADINI: Versus 2A subsquare.

MR. BASU: 2A red square is injection for RPV, low pressure failure.

MEMBER CORRADINI: And then --

MR. BASU: And then subsequent --

MEMBER CORRADINI: -- the blue circle under 2A is main steam line failure, right?

DR. ESMAILI: Okay, so I actually had to write it down case by case so --

MEMBER CORRADINI: Okay, sorry.

DR. ESMAILI: So let me tell you what happens. Let's talk about 2A. It's easier because, you know, when you look at all the other -- so in Case 2A forget about all the main steam line creep rupture.

MEMBER CORRADINI: Forget about that?

DR. ESMAILI: Forget about that, yes. So right now --

MEMBER CORRADINI: For now?

DR. ESMAILI: For now the cesium release fraction to a 2A. These are Cases 10 and 11. This is below 1 percent. This is because you are injecting water, et cetera, right?

The one that's up there, this one here, the dark blue one, is exactly the same except that at some point I assumed that I stopped injection. Okay, this was just an assumption, that, you know, we do inject for a while. Once the water level reaches about 21 feet inside the wetwell, then I stop injections. Instead of throttling, I stop injection. That's not water management. That's not water addition. But we just wanted to see what happens.

MEMBER CORRADINI: Okay.

DR. ESMAILI: The releases go up because at some point you are going to get the drywell head to leak so the releases go up but it's not much. I mean, you can see.

And actually what is really interesting is that even when we stop the injection for this case, I still don't get a liner melt through because I stop the injection very late into the accident and it takes some time for the debris to heat up. It just never becomes mobile enough to go and fail the line.

MEMBER CORRADINI: And the reason we're failing the dry run, I'm sorry to drill down just a little bit, the reason we're failing drywell is buildup of noncondensable gases from hydrogen generation that makes the red square even higher and I start leaking through the drywell, because the rest is condensable.

DR. ESMAILI: The drywell failure is only happening because the temperature inside the drywell has reached high enough temperature so I'm leaking gases from the other drywell head.

MEMBER CORRADINI: Okay. I'll stop. Thank you.

DR. ESMAILI: I understand. I will try to, when we actually write down everything we'll trying to explain but --

MEMBER CORRADINI: But you discounted the ones with the arrows pointing to them because they are extremely low probability or --

DR. ESMAILI: No, these just tell you that in a Mark I as soon as you get the main steam line break, this is, you know, you have, it's a direct path into the drywell. At the same time you have failed the upper head also. Okay, so there is a direct release from the RPV to the drywell and to the atmosphere. So these are the ones that have the highest release fractions to the atmosphere.

MEMBER CORRADINI: The first two parts of your explanation I understand. The last one, I don't. Why is there, this is a failure eventually in the drywell, not immediately in the drywell. The way you described it, it's time phased so --

MR. BASU: So we are not discounting. Remember I said MELCOR is deterministic but calculated.

MEMBER CORRADINI: I understand.

MEMBER BLEY: I can't quite hear. You said --

MR. BASU: We are calculating for our main steam line rupture. We are calculating low pressure failure of the vessel ultimately leading to release. We are calculating the drywell head flange leakage. We are calculating all these things.

MEMBER CORRADINI: Okay, but just to say it straight through and then I'll stop, is that somehow the SRV cycling fails. It fails closed. I keep on heating up. I fail main steam line.

MR. BASU: That's correct. That's right.

MEMBER CORRADINI: Eventually I heat up drywell. Drywell leaks directly into --

DR. ESMAILI: Well, actually this happens almost immediately. As soon as you get a main steam line break, you are going to fail the containment. That means the upper head.

MEMBER CORRADINI: Why?

DR. ESMAILI: Because the pressure, I mean, by that time you have, there is some pre-existing, you know, pressure in there and, you know, the pressure's just going to go up. This is even overpressure. This one, we don't even need overtemperature. Overpressure is enough to cause the upper drywell to fail.

(Simultaneous speaking.)

DR. ESMAILI: That's a consequence of that, right. I don't assume anything. It just happens.

MEMBER CORRADINI: I understand that. Thank you.

MR. BASU: While we're on this slide, one more comment, Mike. I think you were talking about I said an order of magnitude, if we are, we are good if we can do that. And so you were saying something like maybe --

MEMBER CORRADINI: What I'm trying to understand is if I take away the MSLVs, then I understand your point, is that there seems to be a relatively uniform set of calculational results, but once I look at the MSLVs it creates questions for me. That's all.

MR. BASU: Yes, yes. Some of those cases, again as I said, a couple of the MSLVs are going to create problems for you. One in particular is --

MEMBER CORRADINI: Raise questions I guess.

MR. BASU: -- when we are doing the drywell vent only and that's just to warn you that if we were to do that, you know, that's going to actually result in --

(Simultaneous speaking.)

MEMBER CORRADINI: Yes, I'm with you. Thank you.

DR. ESMAILI: The other thing is that, this is important, that you open the vent at the time of the main steam line creep rupture if the pressure is high enough that you open the vent.

Opening the vent is not sufficient to prevent upper drywell leakage. So you are venting at the same time the pressure. You cannot relieve the pressure. You're going to open up the vent, so.

MEMBER CORRADINI: And it's not big enough, is it?

DR. ESMAILI: All right, so now looking back at the results for the maximum drywell's structure temperature, I believe that in the afternoon we're going to see some of the industries.

So all the cases that we see here, again, you know, this is the maximum drywell structure temperature. You know, the structure temperature changes. It goes to maximum and then comes down, you know, because there's a lag between, you know, how you are cooling.

But what we'll find out is that as long as you don't have a main steam line creep rupture and you are continuously injecting water, you are keeping the temperatures below 600 degrees Fahrenheit.

So all the cases that you see that are going above 600 are the cases that you either stopped injection or you have a main steam line creep rupture or you have no injection, okay? So as long as you have injection, whether it's inside the RPV or inside the drywell, you are keeping the structures relatively below 600 --

MEMBER CORRADINI: And that structure temperature is where?

DR. ESMAILI: There are two cases. One is the upper head, drywell upper head because that's where --

MEMBER CORRADINI: Oh, I see.

DR. ESMAILI: The solid symbols are drywell head.

MEMBER CORRADINI: Oh, okay. I'm sorry. I'm sorry. I'm sorry.

DR. ESMAILI: Yes, right. So and then the other one is the drywell liner. This is at the location. Should there be a drywell vent, these were the temperatures that we are going to see.

MEMBER CORRADINI: Thank you.

DR. ESMAILI: Okay now, this is -- We also looked at, you know, what happens to the hydrogen. You know, there's a lot of hydrogen that's being generated here.

And we tried to see, you know, is there any difference between either you do wetwell venting first or drywell venting first? You know, what happens to hydrogen?

So what I'm showing here is that -- This is Case 7. The takeaway is that, you know, the blue line represents the amount of hydrogen that's produced inside the vessel, okay? This hydrogen is being, every time you cycle it, it's going to be released into the containment as a result of RPV cycling.

So you see the green line? The green line shows the hydrogen that is inside the containment plus the hydrogen that has been vented, okay? So by about 17 hours, all the hydrogen that has been produced in vessel, okay, is either inside the containment or has been vented outside.

The red line shows the actual hydrogen that remains inside the containment. So you can see as soon as we start opening the vent line we are purging, you know, we are purging the hydrogen. It takes, you know, maybe about two hours to drop the hydrogen to some residual.

So out of the 1,000 kilograms of hydrogen, for example, that you produced in vessel, in about two hours you are bringing it down to about maybe less than 50 kilograms.

In the case of a wetwell venting, some of the hydrogen is still trapped that's inside the drywell because you are venting from the wetwell side. If it's a drywell venting, the purge is almost complete.

But this is, you know, this is a little bit, if you're talking about uncertainty how much are you actually -- This is some residual. I wouldn't pay too much attention to, you know, the differences between, I don't know, 10 or 50 kilograms.

So both wetwell venting and drywell venting are very effective in trying to purge, this is venting hydrogen, this is only the in-vessel phase. Of course when you go up, you know, ex-vessel, you know, you are producing both hydrogen and CO but they are continuously being vented outside.

So the results for the Mark II. So what I'm showing here is that for the cases that we ran both Mark I and Mark II what I find, that overall the releases are comparable, well within the uncertainties, in the sequence-to-sequence that we saw before. So this is something that we expected.

Especially this becomes more true when we are talking about very, very low releases. If you have very, very low releases, this will be dominated by, you know, how much revaporization is taking place so it's very, very difficult to keep track of where everything is. Some of the radionuclides still remain inside the vessel, some in the suppression pool, some is still in the structures, et cetera.

So Mark II actually has a bigger containment. The volume is a containment about 30 percent higher so this tends to reduce the load. So if you remember in case in Mark I, in all the cases that I have main steam line creep rupture, it led to the failure of the containment upper head.

In the Mark II we don't get. So when you look at Cases 3, 42, 44 and 52, these are all the cases with main steam line creep rupture. You see the difference between Mark I and Mark II. Mark II, we don't have the releases in Mark II, whereas you have the releases in Mark I.

Again, as I said before, the SRV was disabled in both cases. I really need to disable the logic for SRV cycling in order to get a main steam line creep rupture.

In terms of RPV versus drywell injection, so I'm comparing Cases 10 and 24, it's difficult to say but RPV injection, at least in the case of a Mark II, appears to be more efficient in terms of reducing the releases but we are talking about very, very small releases so I'm, again, within the --

MEMBER CORRADINI: Maybe you said it's the same but three with the green bar, which case is that? I apologize. I don't remember.

DR. ESMAILI: No, I mean, I don't remember. Okay, Case 3 is the case where you have no injection and leads to main steam line creep rupture.

MEMBER CORRADINI: Thank you.

DR. ESMAILI: So you see releases for the Mark I, yes.

MEMBER CORRADINI: I thought that was.

I just wanted to verify. Thank you.

MEMBER SKILLMAN: What is the volume difference between a Mark I and a Mark II?

DR. ESMAILI: Thirty percent higher.

MEMBER SKILLMAN: Thanks.

DR. ESMAILI: I think the wetwell volume, the water volume is actually the same but the air space is about 30 percent higher.

MEMBER CORRADINI: Thank you.

DR. ESMAILI: Okay, so that's it. That's my presentation. There are a couple of backup slides so I can close it now.

(Simultaneous speaking.)

CHAIRMAN SCHULTZ: Any questions on the backup slides?

(Off the record comments.)

CHAIRMAN SCHULTZ: We have one more presentation by NRC but I'm going to put that off until after lunch. I am going to cut the lunch break from what was on the schedule to about 40 minutes and ask everyone to return at 1:15. At that time we'll start the presentation by Eric Bowman.

MEMBER CORRADINI: You're kinder and gentler than I would have been.

CHAIRMAN SCHULTZ: Thank you. We'll close now for the lunch break.

(Whereupon, the above-entitled matter went off the record at 12:33 p.m. and resumed at 1:15 p.m.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

(1:15 p.m.)

CHAIRMAN SCHULTZ: I'd like to call the meeting back to order following the lunchtime recess. I do want to make a correction. I noted before the lunch break that Eric Bowman would be next up on the agenda. However, we're going to hold his discussion until the closed session later this afternoon. So we will combine it with the discussions on operator actions.

With that, then, we'll start this afternoon's sessions with a report from the industry and I'd like to call upon Steven Kraft to introduce the industry's presentation as well as the presenters. Steve.

MR. KRAFT: Thanks, Dr. Schultz. I am not Eric Bowman, last I checked. I am Steven Kraft, senior technical advisor at the Nuclear Energy Institute and the industry lead for this rulemaking as well as a lot of other activities under the post-Fukushima banner.

To my right I am joined by Rick Wachowiak, project manager from EPRI and my counterpart and the lead for the EPRI work in this rulemaking, and to his right is Doug True who is familiar to all you present at ERIN Engineering and Research and to the far right is Jeff Gabor, vice president of ERIN Engineering.

I would say that the industry would be in a lot worse shape if it wasn't for EPRI and ERIN Engineering both, thinking that Doug and his folks have innovated in both the post-9/11 attack area and then since the Fukushima area.

And I can tell you, and I don't want to embarrass Doug but when it comes to these kinds of decisions, analyses, thinking through the strategy, the industry leadership relies on Doug a great. So we greatly appreciate his participation.

When we get to the -- I jump to a slide that's more or less half a dozen in Rick's presentation because I want to address some of the strategy questions that came up during the course of the discussion this morning and point out that at the very top of the discussion when you had Aby Mohseni and Aaron Szabo up here I thought that Dr. Corradini was asking a lot of the right questions from a strategic point of view.

And in fact, Mike, I would say you were getting into the cumulative effects area I thought in terms of what's important, how does it all fit together, which is kind of the essence of where we think things need to be looked at.

Had we thought we were going to get into those kinds of strategic discussions I would have had several other slides to ease this discussion here but we'll have to do it the best I can with some word pictures.

This might seem sort of elementary, that you have to add water to a containment if you put the core on the deck or preventing the core from going on the deck and putting water in the reactor vessel. That, in fact, is one of the major things you do for every accident sequence beyond design basis.

But the important point here is making that water more reliable in an ELAP circumstance, that's number one, and I won't have to go through. You know far better than I the value of the water in terms of protecting containment.

I want to bring your attention to the takeaway box at the bottom. When the order was written and Aaron went through that with you when you asked the question, it is perfectly acceptable under the order for a utility to install a drywell vent without regard to water injection. They may have to have higher temperatures. It may be a more difficult thing to get done, but there is no water injection requirement in the order.

The order allows you to claim water management and not flooding out the wetwell vent as a way to avoid severe accident drywell vent, and it does beg the question how do you manage water you don't have, but that's what the order says.

And a licensee can make a decision right now that says I'm just going to go put in a drywell vent and I'll deal with water if and when I have to in some manner when the rulemaking occurs. This is an example of how NRC process sometimes gets in the way of what's the right thing to do.

So as the industry began considering, once we got through the guidance for the wetwell vent which is all being done, you know, that's in flight. NRC's reviewing industry plans and people will have those installed over the next few years, severe accident reliable wetwell vent.

It occurred to us that there is an enormous value associated with water addition that goes beyond sort of this idea that you have to have water to prevent things happening in containment.

You have to have water if you have a filter because you have to make sure the gasses actually go out the filter and not some other way out of containment.

And so we came to NRC at senior levels and below and made the recommendation that they resequence the way we're going about the order so that we would focus on the water addition as part of meeting Phase 2 of the order which means, in essence, bringing it out of the rulemaking into the order.

And then what happened was, and this is where I wish I had my diagram, you have three end-states of the order, which I think is the answer to the question you were trying to get at.

Wetwell vent is in flight. We're doing it. It's going to get done, so that's not even a question before us, right? And you all reviewed that when that was an issue for the guidance.

You then face three choices. You can convince NRC staff -- Back up. You can determine I will do severe accident water addition, and we'll get to that definition in a minute, but water addition.

And then you can say, okay, I did that water addition. Now I will convince NRC I have a strategy to manage it sufficiently well so I never under the dominant sequences flood out my wetwell vent and, therefore, I don't need a severe accident drywell vent. I emphasize severe accident. You probably need a drywell vent at some point for something but that's not the same thing, okay?

You could say, well, definitely I'll add water. That makes perfect sense to me, but I either don't have the freeboard to manage the water or I don't want to manage the water.

Maybe my company's culture view is that I don't want to burden my operating crews. That will be a very stressful time to think about just right now the guidance under the SAMG says inject all the water you can, try to achieve four feet coverage of the corium. That would wipe out your wetwell vent without a doubt.

Maybe I don't want to do that so I will select the second end-state of the order, which is water addition plus water management, two different things.

Still have to put in a severe accident drywell vent but I get the benefit of the water and the cooling and I can have a more rational temperature regime from my drywell vent design point which we've agreed, the NRC staff, is 545 degrees Fahrenheit.

You may remember when we were here last, the wetwell vent, the argument over temperatures and things like that. So enough analysis had been done both in the NRC rulemaking analysis and our own that said, you know, 545 is okay.

However, I can say I don't want to engage in water addition now and I don't ever want to touch water management so I will pick that third end-state, which is just put in the drywell vents.

You're accident capable but probably I'd have to come up with some kind of design, 1,000 degrees or more, remember where that's going to tap off and the temperature's up in the barrel portion of the containment. And that may not be a great thing to do.

But here's where the problem comes in and this is what Aby was trying to get at because we talked about this yesterday at the public meeting.

If I'm a utility faced with this decision making, I want to know the rules as early as possible and the problem with the process we're in is we are writing guidance for Phase 2 of the order, yet we're not going to know ultimate answer until we finish the rulemaking, which may or may not include an external filter. That's always a possibility.

Now, Marty said, well, the whole thing started because we want to avoid the expense of filter, something that works well and protects your plant, though it be expensive, you figure out how to use it.

Our problem was our analysis showed that there were lots of times when that filter wouldn't have made a difference so we began to question the filter. It is expensive, but we began to question the filter from a technical point of view.

But if I'm a utility and I'm facing the question of do I put water in now or not, water addition now or not or wait? Well, okay, so our answer back to the leadership was, well, you can delay putting the water in it now. You're stuck with a very expensive drywell vent. Oh by the way, if you do get stuck with a filter, you still have to put water in it. So, you know, it's kind of a pay me now or pay me later.

However, utilities make business decisions. So if you're sitting there and you're saying if I knew all of this at once maybe there's a different decision I make, rather than investing in one thing here only to find out that there's something else down the line I got to invest in that had I known up front maybe I wouldn't have made that first investment. And that's where the, this is what Aby was trying to get at, that's where the process can sometimes lead to suboptimal decision making.

And normally NRC process is a good thing and we always want NRC to stay inside process but we have a situation here where the rulemaking process and the order process are clashing because you're getting different -- Well, we're asking. How do you know what minimum means? Good question. And you're not going to know that answer until well after you're required to make the commitments under the order.

And what I would tell the industry is that if you are, in fact, facing that conundrum, it's easy. File an exemption request. Get out of the schedule requirement under the order and wait until you have the final answer.

Now, that's a problematic thing to do for the agency because of the commitments made to Congress on when all the post-Fukushima stuff was going to get done by so that becomes -- But that is one of the things that we're thinking about and, now, that's where this conundrum all comes in and we're trying to come up with enough guidance so we can help the industry.

Let me answer one last thing before I see if there are questions on what I've said. Eighteen months ago in the very first public meeting with the staff on the rulemaking, we suggested three different ways you could define them.

Our favorite one was so many orders of magnitude below the QHOs as a test for whether or not you're meeting some minimum requirement in the filter. Yesterday was the first time we heard back after 18 months of asking and what we got was that vague answer that you all were questioning.

I just put that out there because it's something we've been thinking about for a long time and we think we have a good idea and so there'll be some future discussions.

But again, it goes to the same point. We're not going to know all the requirements until the end of the rulemaking and that creates a lot of trouble for business decisions because ultimately utilities are businesses.

So before I turn over to Rick, questions, discussion? Have I made it worse?

MEMBER CORRADINI: Oh, I understand what you're saying. I'm not sure about others. I appreciate the comment.

CHAIRMAN SCHULTZ: Good. Okay, well thank you, Steve.

MR. KRAFT: Yes, my pleasure. Let me turn the rest of the --

MEMBER CORRADINI: Can I just make sure? I thought I understood it but you apparently thought -- I mean it makes perfect sense to me but I'm just curious if, the staff also must see the same thing, which is water addition will only have benefit. But your point is that because the way things are structured I may choose to skip over that just because I'm uncertain?

MR. KRAFT: Yes.

MEMBER CORRADINI: Okay, all right. That's what I thought that meant.

MR. KRAFT: Mike, they understand it now because we had this very lengthy discussion yesterday and I have to say, to Aby's credit, and then we spoke, you know, a little more. He definitely does understand it. You know, I think this is a message that was required.

So, you know, because when you talk to industry leadership, particularly to CNOs or to CEOs, is that, you know, they look at a broad range of factors. You know, they'll always do the safe thing but there's a broad range of factors they have to consider. What does it mean to do that safely?

MEMBER CORRADINI: Okay. Got it.

MR. WACHOWIAK: Good morning. My name's Rick Wachowiak from EPRI and we're doing the filtering strategies rulemaking technical evaluation for the industry and we've already been through introductions so just get right to what we're going to talk about.

Our presentation is split into a couple of different phases here. I'm going to go through an overview of what our objectives are in the technical analysis that we're doing.

Then we're going to move over to Doug and he's going to explain how our PRA evaluation works and then finally we'll move over to Jeff and he'll discuss some of the MAAP results that we have that support the evaluation that we've done.

Where we are, we're covering our Mark I analysis and results and we'll talk about the status a little bit later, but our Mark I results are close to complete. We have results of those and we'll talk about our Mark II approach and that is still pending work.

So when we talk about the filtering strategies, we have to make sure that we look at it in the context of severe accident management and it's not any one specific case where we say this is what's going to be happening after some event happens. It's a progression of events that may take several different paths as the situation unfolds and equipment and operators perform or not perform in the way that's expected.

And when we put this in the, as we say here, the context of accident management, we see that in response to events like what happened at Fukushima, the accident management events always require some sort of active operator intervention with the Mark I and Mark II type designs.

And I think it was mentioned earlier this morning that some thoughts of how we could do this in a passive manner could be done, but we get conflicts with the pre-core damage events and that was explained this morning so in all cases we do have to have some active management of the accident.

And our accident management, of course, involves core cooling, decay heat removal and doing something to mitigate the releases using the equipment that we have or something that we might want to install.

Our evaluation looks at the benefits of

all sorts of different things that we can do to perform these accident management functions and looks at the relative benefit of each of those to make a comparison so we can see what we should add and how far we should go. Where do we reach the point of diminishing returns?

Objective here, the first thing we needed to do was put FLEX into our understanding of how the severe accident goes. I think your question this morning about could we use some earlier analyses or something and move forward with that --

MEMBER CORRADINI: That was a bad idea but you can --

MR. WACHOWIAK: Well, the difficulty with it is, and I think Marty may have mentioned this too, is that it doesn't include this new thing, FLEX, that we have. And when we want to look at how to best manage these accidents, we have to look at the most likely sequences, the dominant sequences.

And we'll get into this later but FLEX changes the topology of the dominant sequences by quite a lot and it makes the scenarios that you need to run to consider the type of decontamination that goes on, they're different ones than you would have had if you'd used some previous analysis like 1150 or some other current plant PRA. So that's an important characteristic of our analysis.

We also wanted to make a clear and manageable analysis, something that we can wrap our heads around, so we took a little bit of a different approach and made our event trees and underlying logic models a little more simple, and Doug will get into those, so that we can keep track of all these things and understand what they're trying to tell us without getting into a lot of the minutiae. We do, you know, do consider dependencies and things like that. It's a robust model. It just isn't quite as detailed as what Marty presented.

We've been all along, you heard about this this morning, having dialogue with the staff to make sure that our analysis assumptions and any issues that we have are aligned. And we don't want to get to the end of this and say they got a different answer than we did because some assumptions that we made early on were completely different.

So all along the way, like I think they said, about every month we've been meeting to make sure that we're working on the same set of assumptions. And for the most part I think we're pretty well aligned on most of the assumptions that went into the analyses.

What Steve was just talking about is informing the implementation of the order. We are taking the results from this as we have them now and that's when we realized that it was important to do water management first and try to get that ahead in the industry.

Providing insights to the owner's group on EPG/SAG. We have at least one area in our analysis now where we're trying to recommend additional considerations in the EPG/SAG to maybe make the sequences work a little bit better than they do now. And then also it's to support the cost-benefit analysis, ultimately for this whole project.

CHAIRMAN SCHULTZ: Rick, with regard to your comment about the framework of the model being robust but not being as detailed as what Marty presented earlier, are you having any difficulty in assuring that with what you have developed there's good communication between you and the NRC on these key issues of decision making and evaluating both the evaluation as well as the overall aspects of the analysis?

MR. WACHOWIAK: I think so. Now we're first starting to see the NRC results, whereas we've seen pieces of the model before. And what it looks like now is, you know, they're not too far off in the answers.

There's, you know, some small differences but for the most part it looks like their analysis is coming to the same types of conclusions that ours is in the probabilistic analysis so the aligning meetings that we've had I think have done quite a bit of good in that.

CHAIRMAN SCHULTZ: Good. Thank you.

MR. WACHOWIAK: So where are we in all this? We're completing the BWR Mark I evaluations. We've got the baseline cases done, alternatives for our reference plant. We're analyzing one plant in this and then doing sensitivities to address the rest of the Mark I fleet.

We're pretty much done with the reference plant. We do need to do the sensitivities. We haven't gotten into those and we're reviewing the results of the reference plant now.

On the Mark II, we're preparing this. We have the approach defined for how we want to do the Mark IIs. Once again, to make sure we have alignment on this, the NRC asked for a bunch of information on the configuration of the various Mark IIs in the industry and we're using that same information to inform our model so we should have the same design information as the NRC when we do these runs for the Mark IIs.

One thing, though, that we're seeing is we're not quite sure how we can do this with only one reference plant. We think that the pedestal configurations are different enough that it's going to require more than one reference plant to do this and not be able to just do it with sensitivities.

We're still looking at that right now but our preliminary conclusion is that we probably are going to have to do more than one configuration when we do our analysis.

MEMBER CORRADINI: This is because of physical geometries or maybe the equipment --

MR. WACHOWIAK: Physical geometries. In some of the Mark IIs, like the one described, Doug's going to get into that.

MEMBER CORRADINI: Yes okay, fine. That's fine. We can wait. I can wait.

MR. WACHOWIAK: So what we've found so far. I mentioned this at the outset, that operator actions are essential to managing the accident, both the pre-core damage operator actions to hook up the FLEX equipment and to make the FLEX strategies work and the post-core damage assessments to get the water in and to manage the releases.

One of the things we did find so far in the probabilistic analysis is we do get a substantial benefit, safety benefit from the addition of FLEX and we expected that when the FLEX program started and this is probably the first time that anyone's attempted to quantify what the magnitude is.

And once again, our objective wasn't to figure out that magnitude. It was to understand how the dominant sequences shifted around once you put in this new equipment. But we do find that there is a substantial benefit from adding it.

MEMBER STETKAR: Rick, this morning we talked a little bit about that and I thought that it looked like FLEX was buying you about a factor of two in --

MEMBER BLEY: The screening values, the HRA.

MEMBER STETKAR: No, with the HRA zeroed out.

MEMBER BLEY: Well, from a 0.3.

MEMBER STETKAR: Yes, from a 0.3.

MR. WACHOWIAK: The equipment itself.

MEMBER STETKAR: Just the equipment itself.

MR. WACHOWIAK: And I think Doug has a slide on what it is but it's about five.

MEMBER STETKAR: Okay.

MR. TRUE: Yes. That included the equipment reliability so if you fully took FLEX out, you'd get another increment of improvement, right? Because he just zeroed out the operator, right?

MEMBER STETKAR: He just zeroed out the operator --

MR. TRUE: But the equipment there, the FLEX equipment there is just --

MEMBER STETKAR: Okay.

MR. WACHOWIAK: And like I said, we have a slide on that but it's around 5. We have to have water addition and our analysis, right now at least, shows that if you put the water in through the RPV you get a little better removal of fission products than if you just spray it onto the drywell floor itself, and Jeff will talk about some of that.

When we look at other filtering strategies in addition to the water addition, there are some benefits in some of the sequences, but when we focus on the dominant sequences, there's only a marginal benefit for the other strategies.

And we'll get into this as we get through the results but, you know, you can take any one scenario and find something to make the release a lot less but then when we go back into the PRA, we find that these are 10^{-10}, 10^{-11} sequences that are being affected. And the ones that really drive the off-site consequences, the water addition gets us almost all the benefit we need in those scenarios.

We think that the Mark II response might be a little different than the Mark I but we've seen nothing to date that suggests that water addition is not going to be one of the requirements for the Mark IIs. So we think that insight is going to hold up but the details of the other things, what else can go with it, we're not far enough yet.

We talked about the, or Steve talked about the value of water addition. You know, it does several things for us. It preserves the containment boundary by avoiding liner melt through. It reduces the temperatures in the containment and greatly reduces the challenges of, you know, the containment boundary and any other equipment that might be relied on for venting and things like that.

And it does work to reduce the airborne fission products, in some cases by, you know, cooling materials or cooling surfaces where fission products have deposited and now they're not going to revaporize and things like that.

So we understand that there's benefit of the water addition and we understand why the water addition works the way it does and, as Steve said, we've moved this ahead, tried to move this ahead to take maximum benefit of that particular insight.

In the upcoming presentation, we have two new terms. Severe accident water addition, I've talked about this. It's SAWA on some of our slides. And that's just providing water into the containment, whether it's through the vessel or through some other dedicated line into the drywell, but SAWA is adding the water. Then managing it is, what do we call it? SAWM.

MR. TRUE: SAWM.

MR. WACHOWIAK: SAWM. That is where we're managing the amount of flow that goes into the containment such that we preserve the wetwell vent path and that's the whole objective of SAWM, is to preserve the wetwell vent path.

CHAIRMAN SCHULTZ: We might want to call it water management.

(Laughter.)

MR. KRAFT: Well, you know, it's funny. When we first hatched the ideas and we were calling it water addition, water management, we decided to add the severe accident first because that drives a lot of the capability.

So unfortunately we ended up with acronyms. There were other acronyms that I don't think I want to repeat, so we'll just leave it at that.

MR. WACHOWIAK: So on the slides if you see these terms, this is what they mean.

MEMBER BROWN: Can I --

MR. WACHOWIAK: You can go ahead.

MEMBER BROWN: Water addition, water addition, water addition, water addition, very, very important, but yet I'm trying to remember your takeaway from your part was downstream, depending on this process approach, the business decision may be to not do water addition, but did I miss that?

MR. KRAFT: Well, no, you did not. The order, the way it is written now allows a utility to ignore these two factors completely and simply do severe accident drywell vent and call it a day, very expensive thing.

MEMBER BROWN: The order --

MR. KRAFT: It does. Now, ultimately the rulemaking might drive something else. So my point was is that if you're going to make a good business decision you need to know all the requirements in advance, not have them --

MEMBER BROWN: I don't disagree with that. You probably heard the earlier part of the meeting. But if this is so important and even though the order says you could probably, you guys could walk away, just say, hey, we're going to do the vents and that's all --

(Off the record comments.)

MEMBER BROWN: Until the rulemaking. Well, it may not come down in the rulemaking. I mean, that's their point. If this is so important to the severe accident management, why wouldn't you just go ahead and do it and bypass all this other chifafa that everybody's talking about?

MR. KRAFT: Yes. You know, I like the word chifafa. That definitely is a good image.

MEMBER BROWN: That's a Kentucky terminology from when I was raised up, okay?

CHAIRMAN SCHULTZ: Why isn't it the right business decision? If you look at it from a broader perspective than just a financial one --

MR. KRAFT: Yes. I completely agree.

CHAIRMAN SCHULTZ: -- why is it not the right business decision?

MR. KRAFT: I completely agree because --

CHAIRMAN SCHULTZ: Because business is more than what you spend. It also has to do with whether you're going to be able to operate your plant, for example.

MR. KRAFT: Exactly right. I'm not seeing --

MEMBER BROWN: Do we just terminate the discussion then because you now have a direction?

CHAIRMAN SCHULTZ: I understand.

MEMBER BROWN: No, well, I'll stop.

MR. KRAFT: There are a couple of utilities, fleets that are in certain markets where certain requirements are life and death. So if you're facing a situation where you say, well, okay, I could do water addition because of what it -- I mean, there's no question. No one worth his beans in this business, you know, comes up with a different answer.

But as a business decision, you're asking a CNO to bet that water addition is all he's going to have to do. If he's going to have to do more down the line and he knew that up front and that would have changed the business decision, that's something they want to know now, not invest in this and then have something else in the future.

So I just would make that point, that there are reasons why -- And then to make it more complicated, often in the utility business a delayed requirement has a financial benefit because time value of money and get it in your risk profiles and everything else. So we've seen that happen too. Moving decisions to the right often, sometimes works too. But I would --

MEMBER BROWN: Sometimes it doesn't though, so.

MR. KRAFT: Sometimes it doesn't and what we've tried to explain to the industry leadership, particularly last week, was that if you don't adopt at least water addition, it's a very expensive pathway with that vent because it's a very high-temperature vent and that's going to be very difficult to prove. Doesn't mean they wouldn't say, well, I can figure that out. I mean, there's lots of different ways people could slice and dice this.

So the only thing I was -- And again, we didn't go through all the details but in the rulemaking analysis the fact that because we moved water addition into the order, the cost of water addition or a sump cost in the cost-benefit for the filter or other filtering strategies and that could alter decisions as well.

So that's why I mean these two processes, which by themselves are very good, could be clashing and alter the way, you start making suboptimal decisions at the business level and that's really what I was trying to get at. It goes to Dr. Schultz's question too, I mean, so it's the right thing to do. No one disagrees, but business decisions have to be made.

MR. TRUE: Okay. This is Doug True from ERIN Engineering. I'm going to do a kind of flyover of the technical evaluation framework and then Jeff's going to get into some of the analytical results for MAAP. And then I'll come back on and talk through some of the results and insights from our preliminary quantifications.

So we actually headed off on this I think frankly ahead of the staff a little bit and we provided what basically is our model sometime last year, like last August or something like that, to the staff so that's helped us stay aligned and understanding gaps.

Our philosophy was we wanted to sort of start with SECY-12-0157 methodology and the SOARCA reference plant to try and move this forward and we wanted to do that in a very open and interactive way so that we could align our assumptions.

One of the conundrums that we were presented with immediately was the SECY-12-0157 hadn't taken any credit for the fact FLEX was going to be implemented and this water addition concept is predicated on sort of repurposing FLEX capabilities to be able to support water addition.

So you get into this logical conundrum that says, well, if FLEX failed, how can I credit FLEX for severe accident water addition? What are the circumstances under which repurposing in that manner is really going to help you? And so --

MEMBER CORRADINI: Okay. Generation III+

plants used to say what?

MR. TRUE: So we set out early in our initial work was to sort of understand what scenarios is FLEX going to help you with, which ones is it not going to help you with and what do those look like if you get past the point and core damage, because whole purpose of FLEX is to prevent core damage.

So the other thing we wanted to do was to take advantage of the assets that the industry has in terms of MAAP and its fast running capability to be able to do explicit analysis of all the scenarios.

So you'll see in a few minutes we've got 13 core damage end states and 39 APET end states, 507 or so scenarios. We actually run a MAAP case for every one of those to look at that analysis and then tie it into MACCS.

And that gives us a really good understanding of what's going on in the plant response that we can then use to help inform some of these risk management insights.

And by linking that to the probabilistic framework, we can actually then begin to really understand probabilistically what's important and what the output looks like in a probabilistic context.

We're looking at it from a risk standpoint but we're also looking at it from a defense in depth perspective. I think Aaron earlier today mentioned the fact that we were the ones that brought up conditional containment failure probability as a metric to be considered in the process because preserving the containment boundary is an important aspect of managing an accident. If you fail the containment boundary, then whatever else you do, including putting filters on, isn't going to be very helpful.

EPRI's work is limited to the actual analysis and calculating averted impacts by different changes. The actual cost-benefit analysis will be done by NEI. And so this work that we're presenting here from EPRI will eventually feed into an NEI cost-benefit analysis. But it also has helped even so far in helping the execs understand kind of the tradeoffs and benefits of particularly water addition.

The simple framework also gave us some means to look at sensitivity. So one of the ways we got around having to do quite as much detail as Marty did is we're going to attack those things by trying to narrow down the analysis through sensitivities on both the probabilistic side and on the thermal hydraulic side. When we get to the end of the presentation, we'll talk about what we're planning there.

But we can take out, you know, what if you assume that there is no structural damage to the facility and you're just looking at a plant response without an impaired infrastructure? What importance does the operator have? What importance does the FLEX equipment have, its reliability? And so by using this simple framework, we think we can get a lot of the insights that we need to get in order to guide decision making.

Human reliability has gotten a bunch of mention here. I think, my opinion, there's not really a method we've ever used for things like FLEX and so we're in kind of little bit of uncharted territory. Getting consensus on the value should be X or Y for this particular scenario is going to be difficult.

So human reliability is another area where we think sensitivities are an appropriate way to look and understand what's going on in the accidents. And frankly, as Rick pointed out, humans have to manage the accident. If the humans don't do anything, it's going to be a really bad day.

And so what we want to do is inform what are the circumstances under which those operators might be asked to take actions to make sure that we're putting in place the right actions and capabilities for them to be able to manage the accident.

MEMBER BLEY: You know, nothing comes to mind but I haven't heard anybody talk about this. Have you guys thought good and hard conceptually about all of the different kind of scenarios that could exist and is there anything about these designs we're looking at putting on the plants that if they were misused could raise the risk in certain scenarios? Have we thought about it? I can't offer anything.

MR. TRUE: We sort of stumbled across one and Marty mentioned this yesterday. The whole notion of having a completely passive vent system actually increases core damage frequency because it fails FLEX by not being able to do the anticipatory venting.

And so we sort of logically said, well, why would we look at a case where we were going to make the plants less safe? Even if the filter did a good job, at the end of the day we better keep the core intact.

MEMBER STETKAR: Let me just say there is some experience from things that have been done in Europe that shows worse releases with a purely passive vent. Purely passive vents are not necessarily good for the world.

MEMBER CORRADINI: What do you mean, John, by purely passive? Like a rupture disc?

MEMBER STETKAR: Like a rupture disc, an unisolable rupture disk.

MR. KRAFT: Yes, that's because we looked at --

MEMBER STETKAR: An unisolable rupture disk.

MEMBER CORRADINI: That's what I thought you meant.

MR. KRAFT: We looked at this question of passive versus active. There's no such thing as a passive vent because you have to reisolate in order to prevent the problem that --

(Simultaneous speaking.)

MEMBER STETKAR: Well, they were looking at, you know, requirements for just a pure rupture disk. A filter and a pure rupture disk must make things better because how could it be better than that?

MR. KRAFT: Right. But then you've got an open containment for the rest of the event, right?

MEMBER STETKAR: Oh, yes.

MR. WACHOWIAK: So to answer your question about what we've done to help alleviate that --

MEMBER BLEY: Have we looked systematically? That's what I'm wondering, if we --

MR. WACHOWIAK: We have several people on our team that are working with us that have operating licenses at BWRs and they would be looking for things like that. Now, if you tell them to do this, it's going to, you know, we'll have problems.

We're also feeding this back in through the Emergency Procedures Committee at the BWR Owners' Group and they look for those kinds of things as well.

So systematic look at every step? Probably haven't done that yet but we do have some things in place that will --

MEMBER BLEY: Will help catch.

MR. WACHOWIAK: Yes, if we really have neglected something egregious, they'll tell us.

MR. TRUE: Okay, cases or alternatives or whatever, however you want to refer to them. You guys' heads are going to explode because everybody's got a list, a case of alternatives. They're all basically the same. We've introduced the SAWA and SAWM --

(Off the record comments.)

MR. TRUE: And basically the message here is we're aligned I think on the cases. I think the staff's running a couple cases we're not and maybe we're running some cases they're not. But basically the key cases all overlap.

Everybody's nomenclature is different and even within our presentations, just like the staff, we have some cases where we refer to an old number's game and a new number's game but I think the labels get you what you need in terms of what we've been looking at.

The next slide is a matrix of the 24 cases that we're actually going to look at. I don't want to go through it in detail. You can just sort of see from the headings the different features that we are looking at in the alternative cases and the cases just kind of had a permutation, logical permutations of those different alternatives.

The color scheme is red is no water addition, green is water addition to the RPV and blue is water addition to the drywell.

MEMBER CORRADINI: Oh, this is just the water addition, not water management?

MR. TRUE: Water management is here in the column right next to it.

MEMBER CORRADINI: Oh, sorry.

MR. TRUE: Yes. So there's a lot of cases with water, with water to the RPV but no water management.

(Off the record Comments.)

MR. TRUE: Throttling to preserve the --

MR. WACHOWIAK: It's agnostic of that. Water management means preventing the wetwell vent from needing to be isolated. In our MAAP cases we're doing it with throttling but there are other ways you could do it and we're not prescribing yet how to do water management, just the outcome.

MEMBER CORRADINI: Okay, and then one detail. Maybe you can postpone me. At what point from an operational standpoint can one not get above? In other words, at some point you have enough water in there. You've got to stop.

MR. TRUE: Right.

MEMBER CORRADINI: And is the specification different with each of the different geometrical designs?

MR. TRUE: Yes.

MEMBER CORRADINI: Okay. I was afraid of

that.

MR. TRUE: But we collected all our data for all the plants, provided it to the NRC so we're looking at the same set of information there.

MR. WACHOWIAK: And for some plants it's not a hard and fixed value. It has some flexibility and the reason it's there is because of where instrument ranges and things like that are so that's why we're not trying to specify exactly how you do water management but we're specifying what the outcome of water management is at this point.

MR. KRAFT: Yes. For example, there's one plant by moving an instrument set location you can gain three days on water injection so it's those kinds of things the guidance will have people looking for.

MR. TRUE: And in all cases the freeboard we're talking about is, you know, at least hundreds of thousands of gallons if not a million gallons of freeboard that we're trying to manage within. It's not like we're trying to manage within, you know, tens of gallons in volume in these containments so it's a pretty broad band we're managing within.

MEMBER CORRADINI: Okay, thank you.

MR. TRUE: So this is our basic framework, not dissimilar in some ways from the one that Aaron presented. So we started with the core damage of entry. We have a Mark I accident prevention of entry. Later on we'll talk about the Mark II. We have MAAP runs for each explicit sequence, MACCS runs that tie directly to those MAAP runs. That then gets combined into a benefit model.

Then we look at alternatives and we go back and we change whatever we might need to change, whether it's the core damage or APET or MAAP models. And then we have various sensitivities that we'll run to investigate how sensitive those results are to some of those inputs.

CHAIRMAN SCHULTZ: And, Doug, when you call sensitivity -- Earlier you had mentioned sensitivity analyses associated with the different plants. Is that what we're still talking about here or do you also --

MR. TRUE: No, there's a whole bunch of sensitivities. Different plants will be looked at.

CHAIRMAN SCHULTZ: So that's one subset of sensitivity?

MR. TRUE: It's one subset. There are some phenomenological uncertainties we want to look at --

(Off the record comments.)

MR. TRUE: -- in particular looking at the --

(Off the record comments.)

MR. TRUE: Yes, and then some probabilistic ones also.

MEMBER REMPE: Will you be talking about phenomenological ones?

MR. TRUE: Yes. We have a couple on the last slide and particularly in the Mark IIs we may even have some more things we want to look at too.

CHAIRMAN SCHULTZ: I'm glad you made mention of the volume of water. That was a different description of water management than what was discussed a year, year and a half ago which seemed to be a little here, a little there.

And the magnitude that you mentioned has, I'm sure, made some people feel a lot better about the potential benefit as well as the differential that you would have if you actually get into that mode of control.

MR. TRUE: Right. Yes. Yes, it's --

CHAIRMAN SCHULTZ: At one point I heard, well, if we're talking 10,000 gallons then we shouldn't get involved with it, but you're describing it differently now.

MR. TRUE: Yes. And that's, you know, based on the data we've actually collected and we knew that all along but we have hard data for that now.

MR. WACHOWIAK: And one of the other insights that we have from the analysis we've done so far in the Mark Is is that if you attempt water management and it doesn't succeed, the off-site consequence differences are minimal. So it's not very sensitive to being exactly right on, on that more complex action.

MR. TRUE: Okay. I have the advantage of not having given John this in advance, so --

(Laughter.)

MR. TRUE: And it's unreadable, which is also intentional. No. The main point here is it's a much smaller event tree than the one Marty went through. Like I said, we have about 13 core damage end states and I think Marty had 130 or around that ballpark so it's about one-tenth the size.

We have in our quantification attempted to keep track of all the dependencies including operator action dependencies.

So, you know, for example, there are two different nodes here, a wetwell and drywell vent. If the operator failed to open the wetwell vent, then pretty sure he's going to fail to open the drywell vent. If it's a hardware failure that failed the wetwell vent, then he's going to be more likely to open the drywell vent. We tried to quantitatively keep track of that as best we can within the kind of arcane rules we have for HRA.

MEMBER STETKAR: You take care of that across the transition from this tree to the accident?

MR. TRUE: Yes, yes, in the accident -- one of the main differences, I think Marty tried to create end states that helped him do that, which was smart in a lot of ways. I'm doing it kind of offline which makes it harder on me and so he's just smarter than I am to have figured that out up front.

So the kind of nodes that we have in the tree are listed in this next one. You know, we start off with an ELAP. RCIC is questioned early and then if RCIC works initially, do we get that transition to FLEX to get the injection pump and DC power restored?

MEMBER BLEY: Now, have you allowed any opportunity for delays or damage in FLEX due to either maintenance activities on that equipment or due to the chance of actual failures associated with the building? That's sort of the stuff John raised this morning.

MR. TRUE: The building storage?

MEMBER BLEY: It's a seismic one, right? So it has --

MR. TRUE: Yes.

MEMBER BLEY: In the vents we care about, it has some chance to fail as well.

MR. TRUE: Yes, with the risk of getting best design for the seismic design basis, so.

MR. KRAFT: No, but you don't have to have a seismic one. You have diverse buildings too.

MR. TRUE: So we didn't really come prepared to go into all the details of this but let me say a couple of things about that. One is we're sort of treating infrastructure failures as a path to you're done, kind of a path.

So we have a seismic fragility associated with infrastructure damage that would include loss of DC. We based it on a lower meeting capacity than some of the numbers we talked about this morning which I think is represented of whether it's just structure or other values out of that same RASP Handbook but lower capacity values, about half or less than half the immediate capacities that we talked about this morning.

Now, we didn't do every single plant in the country the way Marty did. We did a single reference plant so that's another difference. But, again, we'll do a sensitivity and we kind of look at what, you know, how does your picture of these alternatives change as you change that?

MEMBER STETKAR: Hey, go back to your event tree structure. I assume what you said is seismic failure of infrastructure goes to gory death. I'll use the technical term gory death.

MR. TRUE: Yes, CD-020.

MEMBER STETKAR: How was that actually implemented in this event tree structure? Do you just assign failure of infrastructure to --

MR. TRUE: CD-020.

MEMBER STETKAR: CD-020, okay.

MR. TRUE: Yes. I mean certainly you could go to a lot of detail and look into the structures and things.

MEMBER STETKAR: The only reason I ask is back on your Slide 19 you had this nice little color picture about what contributes to RCIC failure. Does the --

MR. TRUE: Do you want me to jump ahead?

MEMBER STETKAR: Yes.

MR. TRUE: Oh, I'm going backwards. Sorry.

MEMBER STETKAR: Well, you can jump backwards far enough until you circle around. Go back, 19.

MR. TRUE: Oh, my RCIC, yes.

MEMBER STETKAR: There you go. That bottom band there says Based on RASP Handbook Limiting Seismic Fragility for Electrical -- Okay, so those are words. Am I to believe that -- What fraction of that dark, whatever color it is, brown sort of looking thing, is gory death? All of it?

MR. TRUE: The dark red, right.

MEMBER STETKAR: All of it is?

MR. TRUE: Yes.

MEMBER STETKAR: Okay, thank you.

MEMBER CORRADINI: What was your question?

MEMBER STETKAR: We're communicating. It's fine. I asked a question. I got an answer.

(Simultaneous speaking.)

MR. TRUE: Then we look at different time phases. Well then, you know, once FLEX is functioning, then -- We've talked about this anticipatory venting. We need to be able to vent the containment. The operators need to control RPV pressure along with that in order for FLEX to function long term. And then for other scenarios FLEX may not be needed until, may be needed early or late.

And then containment isolation. One of the things that came up in some of our earlier discussion was, well, you know, what if the containment was vented pre-core damage? What happens? So we've actually included a node to ask does the operator reclose the vent once they've lost injection, and I'm sure Marty has done the same thing.

Just forward you to that. This is a less readable accident progression event tree, again simplified somewhat. Three basic pieces of this are, and then the structure's pretty much the same. The top row is an SRV seizure or operator action to depressurize the RPV.

I'm sorry, main steam line's the top one. So a main steam line failure is the top one and Hossein talked about that as a phenomenological possibility.

The middle set is an SRV sticking open or the operator in cases where he has power and capability depressurizing and the bottom one are the high-pressure melt cases, some fraction of events where we don't get to depressurize.

Rest of the questions are asking, you know, do we get water in? Do we cool the debris? Do we avoid liner melt? And then what are we doing with our containment venting strategies? And those are kind of outlined in this next slide.

For the case where we're injecting into the RPV or providing a capability to inject in the RPV we look at in-vessel retention. I think Marty presented some results showing his results for that also.

But the tree is set up to be kind of agnostic on where the water is going and then we'll have Jeff have MAAP figure out what it means to go either to the RPV or drywell for the case we're particularly running.

So what we end up with are a set of contributors that look like this. First scenario, largest scenario is an early RCIC failure and I think we talked about this this morning or you all talked about this this morning, that RCIC's needed to function during those first few hours to get time for the portable capabilities to get put in place.

However, if it's unavailable or it's a gory death day or whatever, then it's not going to function which means FLEX is going to be ineffective in preventing core damage. It's still available. It wouldn't be there in time to prevent core damage.

The next scenario is the more traditional scenario of RCIC succeeds early but then when we go to make the transition to FLEX it doesn't work, either because it's late or it doesn't get implemented properly or equipment fails.

The third scenario is kind of like --

MEMBER CORRADINI: Can I ask about that one?

MR. TRUE: Yes.

MEMBER CORRADINI: Because that one I guess interests me, which is that somehow RCIC's working and it poops out and then hours later, 20 hours later FLEX arrives and then it's now used for more mitigation than for prevention. Is that included in that?

MR. TRUE: No, this is just up to core damage. So we would still ask the question based on what happened here, is that FLEX equipment effective up to core damage?

MEMBER CORRADINI: Oh, this was just up to --

MR. TRUE: Up to core damage, yes.

MEMBER CORRADINI: Okay, I'm sorry. I'm sorry. Okay, sorry.

MR. TRUE: So I'm just trying to get a picture of what in our model contributes to core damage.

CHAIRMAN SCHULTZ: In your first set there, Doug, with regard to FLEX, is that on-site equipment --

MR. TRUE: Yes.

CHAIRMAN SCHULTZ: -- as well as the off-site?

MR. TRUE: At this point it's RCIC early. It would be only the on-site stuff because it's well before that 24 hours.

CHAIRMAN SCHULTZ: That's what I thought. That's what I was remembering this morning. Okay, thank you.

MR. TRUE: And I think our boundary conditions are similar to Marty's in that we were looking at 72 hours as the point at which you get significant additional off-site equipment available.

I didn't take credit for the equipment

reliability I might get out of, they're called now National SAFER Response Centers equipment because they deliver at 24 hours basically redundant equipment for makeup and power supplies. I didn't take quantitative credit for that.

MEMBER STETKAR: It's perfectly available?

MR. TRUE: Perfectly unavailable.

MEMBER STETKAR: Oh, unavailable in the first 24 hours but once --

MR. TRUE: I only credited the on-site equipment for the 72 hours.

MEMBER STETKAR: Yes, okay.

MR. TRUE: I didn't take credit for the fact it would be backed up. Got too complicated to keep track of where am I in the accident progression to know whether I can take credit for it.

MEMBER CORRADINI: So you only took credit if you could get to 72 hours?

MR. TRUE: Yes, basically at 72 hours we kind of cut it off because at that point the view I think of FLEX has been that you're starting to enter into the recovery phase.

You've got lots of resources from the

National SAFER Response Center. You've got big diesels. You've got much more capability, big water capacity pumps. You've got a lot more capacity to start dealing with the damage situation that you have, whereas the first 72 hours or so you're just coping. You're trying to get through that coping period and it's very hard to model what happens when you get that far out in time with those kind of capabilities.

CHAIRMAN SCHULTZ: Marty, I'm going to ask you to come to the microphone to respond because I had the impression that in the NRC's analysis that you had a 24-hour time frame. Is that not correct?

MR. STUTZKE: No. When we looked at the event tree this morning, there was a 72 in there and I remember changing that to 24 but the idea is there's no credit --

CHAIRMAN SCHULTZ: Just on the display or in terms of the analysis?

MR. STUTZKE: No. No, there's no intended credit for the equipment that comes from off site.

CHAIRMAN SCHULTZ: Okay.

MR. STUTZKE: Because as Doug has pointed out, it gets really hard to model, to manage all the scenarios.

CHAIRMAN SCHULTZ: That's fine. I just wanted to make sure that we were consistent between the two analyses.

MR. STUTZKE: Yes, we're consistent on that part.

MR. TRUE: Okay. Then we have some other flavors of RCIC succeeds early but we didn't manage the suppression pool temperature so we then lost RCIC and we had to get the FLEX portable pump realigned to make makeup and it didn't work.

Some other late ones were, you know, things worked but then eventually just fail and then some other venting-related ones. So those scenarios end up comprising almost 99 percent of our total core damage frequency.

It's a little different than what so far Marty has generated. I think he has a little bit less of the early RCIC failures and I think, my personal suspicion is that that's because he used a little bit higher failure probabilities for the FLEX failures which leads me to some discussion about them I would jump forward to.

CHAIRMAN SCHULTZ: Did you want to come back to this, Mike? Because I think it's important.

MR. TRUE: I'll go back to that.

CHAIRMAN SCHULTZ: Oh, okay. Go ahead.

MR. TRUE: I want to make this point though. A traditional PRA person -- We had to work through this with the industry. A traditional PRA person thinks about what contributes to ELAP core damage frequency in this mindset generally, that the smaller contribution comes from the early RCIC failures and the greater contribution comes from RCIC works and then you fail to recover off-site power.

By implementing FLEX, it doesn't really help impact the CDF for the scenarios where RCIC didn't work. It does reduce the risk associated with these longer term scenarios.

So your picture of what's important, and you can make that blue bar as tall or short as you want, but the message here is that the impact is on that blue bar. And so now you're dealing more with these short-term scenarios and less with the long-term scenarios.

Well, the interesting thing about the short-term scenarios is the FLEX equipment couldn't have worked. The operators couldn't have failed because they just didn't have enough time, which means that from a filtering strategy standpoint there is a viable role for the water makeup systems because there's time between core damage and containment challenge to use that same capability, repurpose it for water addition. Follow me?

MEMBER CORRADINI: I think I do. Can I say it back to you?

MR. TRUE: Yes.

MEMBER CORRADINI: So where FLEX's purpose initially was prevention, if somehow things go awry quickly FLEX can still be used in the late time for mitigation?

MR. TRUE: Yes.

MEMBER CORRADINI: And the time between the red and the blue, this fuzzy time in between, is probably plant specific?

MR. TRUE: Yes. Does it work? Yes.

MEMBER CORRADINI: Which --

MR. TRUE: But -- Go ahead.

MEMBER CORRADINI: Which puts your finger right on why it's severe accident water addition, because FLEX is not severe accident. It's beyond design basis but you haven't melted a core.

MR. TRUE: Right. Okay.

MEMBER CORRADINI: Once you've melted the core and certain parts of the plant become inaccessible, you have to think about, in advance, and this is where the SAWA comes in, is that how do I make sure I have a reliable means of adding water in the face of a damaged core?

And in the old boilers given, you know, you know the corners of the plant and everything, there are places where it is very convenient to hook up an external line but you couldn't physically put a human being there if you melted the core because you're 20 feet from the core.

MR. TRUE: Yes.

MEMBER CORRADINI: Right? So you have to think about do I harden that one? Do we shield walls? It may be a fairly simple thing to do but you have to think about it in advance and do something in advance. That's the essence of severe accident water addition.

MALE PARTICIPANT: Well, we did get talking about severe accident here with Mike's comment but this chart is about its influence on core damage contributor.

MR. TRUE: That's the entry condition to the severe accident. So instead of entering in this condition, you're entering in this condition on the right, conceptually. We can quibble over numbers forever, but conceptually that's what we're thinking about.

And the beauty, in my opinion, the beauty of this is that, you know, FLEX was designed to have a certain set of capabilities. It was predicated on certain things functioning in the installed equipment.

By repurposing it to the severe accident water addition, we're getting the safety benefit. It's not totally free because you're going to have to modify the plant, but we're going to deal with a piece of that risk that we had to assume existed in the original implementation of FLEX. So it's a logical progression I think in terms of the evolution of those capabilities. Okay, were we done here or --

(Simultaneous speaking.)

MR. TRUE: This one just gives you an -- And John will probably appreciate this more than --

I was trying to just capture the fact that there are a bunch of things going on that can lead to these early failures of RCIC which would impede the success of FLEX.

And, now, the infrastructure impacts is

one. If it's unavailable for maintenance or it fails to start is another reason. It could fail to run. There's a very slight increase. Turns out the RCIC failure rate, once it's running, is pretty low.

Also stuck open relief valves is another thing that could disable RCIC because it bleeds steam off the primary system and you can't keep running RCIC.

So we ran MAAP and the NRC ran MELCOR and pretty well came to the conclusion that we had more cycles in the first hour and fewer long term after the operator took control and decay heat is reducing. So we ended up with a higher failure rate in the first hour and then a reduced failure rate over time.

So at the end of the four-hour period, which is what we needed it to run for for FLEX to be ready to go, about 13 percent chance. Infrastructure's a pretty significant fraction of that but the SORVs and RCIC failures are not inconsequential either.

MEMBER BLEY: Of course, that also shows us that if one wanted to argue if I was in maintenance I could get it back, that's not a big hunk of, what turned out in red there, it doesn't buy you a whole lot.

MR. TRUE: Right. Also we've gotten

comments about HPCI. You know, well, you didn't try HPCI. Well, you know, HPCI's a backup to this but a stuck-open relief valve where the infrastructure gets HPCI too. So it just gives you kind of a visual of what was driving this.

Okay, so we can then sort of take those core damage scenarios and split them into, I put this in terms of time of loss of core cooling so we got about a quarter of it coming from RCIC's unavailable initially.

The largest piece is actually at that transition point when FLEX would normally be transitioned to, and then some contributors are that running period and then the longer term ones are actually smaller because we've taken credit for the fact FLEX was there and could have been effective in reducing the core damage.

This one takes another kind of slice through the contributors where it broke down the individual contributors of the individual sequences into what is contributing to core damage.

And what jumps out obviously here is the installed equipment, those RCIC failures, the infrastructure failures. Those are the largest contributor. We've got a chunk of human errors over here -- I'm sorry. That doesn't include the infrastructure. That's just the RCIC and SRV failures.

You got a chunk over here for human errors. I decided to split those into two types, one where we had limited time and the reason the operator failed was it was just a really short window for him to succeed in and then one where he had longer time but the systems we use for human reliability are still probability. He didn't succeed.

Failures of FLEX equipment are in here but they're not a huge driver in this whole thing and a lot of that's driven by the M plus 1 capability that's provided. So we've got portable equipment but it's also got a kind of built-in backup within the FLEX system, and we'll do some sensitivities on that and we'll see how that changes the picture.

MEMBER BLEY: The purple box up there with loss of DC and infrastructure, that kind of loss of DC has a seismic loss on paper.

MALE PARTICIPANT: Yes, yes.

MR. TRUE: It's our surrogate for these, yes.

MEMBER BLEY: When it's in that box, you're saying you can't recover it with FLEX?

MR. TRUE: With FLEX.

MEMBER STETKAR: Human reliability using HCR? Okay, never mind.

MR. TRUE: Yes. Thanks. I wouldn't go to the bank with any methodology here so --

MEMBER STETKAR: Well, I'm just trying to get a sense of sensitivity time. That's all.

MR. TRUE: Yes, we cobbled together some is --

MEMBER STETKAR: Go on. Go on.

MR. TRUE: -- the story. So one of the things that the SRM asked for was that the investigation focus on the dominant scenarios, and Marty gave a little bit of this insight for some of what he'd done.

But we started looking at our results and trying to figure out, well, you know, what's dominant mean? You know, we've always struggled with that. Every PRA analyst knows what it is, knows it when they see it.

But so we started looking at particularly our case with severe accident water addition in the RPV. We found that we had about 29 scenarios, or more than about a half a percent. Those captured about 90 percent of the core damage frequency so it felt like a reasonable place to stop.

Once you get below, you know, half a percent, you're down into toothpicks and seeing the forest through the toothpicks can be kind of a challenge.

So this is kind of the approach we're taking, is to try and focus on the larger contributors, not all the small contributors.

MALE PARTICIPANT: But we still count them all?

MR. TRUE: We do quantify them all. We do analyze them all. But in terms of focus on what we're looking at, we try to look at the more likely ones.

MEMBER CORRADINI: Can you say that again? I'm not completely sure what you're saying. You're saying that 99 percent of all the, or 90 --

MALE PARTICIPANT: Ninety percent.

MEMBER CORRADINI: Ninety percent, excuse me, of all this is encapsulated in 29 scenarios?

MR. TRUE: Yes.

MALE PARTICIPANT: For that particular alternative.

MR. TRUE: Yes, out of our 507 possible end states, 13 core damage states and 39 --

MALE PARTICIPANT: APET.

MR. TRUE: -- APET states, 29 of those are actually --

MALE PARTICIPANT: Ninety percent.

MR. TRUE: -- ninety percent of the vents.

MALE PARTICIPANT: Okay.

MEMBER BLEY: And that's on this next slide?

MR. TRUE: Yes. I gave the list here. It's a eye chart as well but you can kind of get a sense of what the scenarios are if you want to spend the time to read it. But you can see it's dropping down pretty fast.

MALE PARTICIPANT: Very fast.

MR. TRUE: And it's not dissimilar from some of the results Marty showed you.

MEMBER CORRADINI: Well, that's what I guess I wanted to, you said it's not dissimilar. So have you had a chance to do a comparison of what Marty had done in terms of how these map over in terms of --

MR. TRUE: I don't think we've seen --

MEMBER CORRADINI: -- and the, I want to say the amount, but essentially is your 90 percent their 90 percent? Or is your 90 percent their about 50 percent? How do the two --

MR. TRUE: Yes, I think, a couple of things. I don't think we've seen, in this detail, Marty's results. Secondly, he's still using some screening values and somehow exactly resolved what we would it compare it to.

I would say that, in the grand scheme of things, we're in the same ballpark. Marty's nodding back there. He's going to have a little skew in one direction --

(Simultaneous speaking.)

MEMBER CORRADINI: -- in Boston and he's in Washington also, same ballpark?

MR. TRUE: Yes. I think we're in the same ballpark. And all I can say, considering all the uncertainties associated with these kind of events, it's probably pretty reasonable.

So this is a lot of data. This is a lot of data. And so of all the things we've been working on in this is trying to figure out how to help people understand what's driving the answers.

So this is something we came up with. It's actually, the technical name for it is a Sankey diagram. And basically think of these as stacked bars, so that the width of each of the bars in a column is the fraction coming from that particular contributor.

So CD 20 is, what, about 30 percent, 20 percent or so, the total? The early RCIC failures are more than half. Those translate to the core damage timing in a certain time frame.

And then you get out here into the APETs, and you can start visually begin to see, while most of these go here, and here and here maybe, and there're smaller pieces that go in some of these other APET end states, but a lot of the APET end states are, A, not listed, because they're not dominant contributors.

And B, even the ones, some of the ones that are dominant end up being pretty small contributors. And then over on the right here we've got what's the release type we're dealing with.

Most of the time it's a wetwell vent. This is a case with water addition, some fraction of the time it's because the water didn't get in or wasn't affected and a small fraction of over-pressure failures where the vents didn't work.

MEMBER BLEY: In your APET end state stack, is there a severity implication of the ones being the top?

MR. TRUE: No.

MEMBER BLEY: No? They're just --

MR. TRUE: I mean, this is done by an algorithm that somebody created. And so it sort of winds them up to give a reasonable presentation. I moved them around a little bit to help get it aligned, which is why we're getting this weird overlap over here. But they're not intended to --

MR. GABOR: One thing that's interesting in this one is the APET-015 is an in-vessel retention case. So if you kind of go backwards, you find out that it had early RCIC failure.

FLEX was available in some of those end states, was unable to prevent core damage but was able to be injected into the RPV prior to core relocation which can yield much like the MELCOR results showed can yield an in-vessel retention. And that has a significant impact on the source term.

MR. TRUE: Yes. And that's because we, in this alternative, we're looking at making FLEX water addition be severe accident capable. So you can do it when it's, opposed to core damage.

So anyway, we think we're going to use this method to walk through each of the alternatives as a way to display how things are changing and evolving across the different alternatives.

And you can even, in the tool -- this is not live because it's tied to Power Point or PDF, whatever we're presenting here -- but you can actually highlight a path. And you can actually watch it and see where it goes through the entire key which will help us explain some of the important contributors and why they're there.

We can also extend this further and look at dollar benefits, where the dollar benefits are coming from, so this is just the release type for the dollar, where the dollars come from for cost benefit. It's a lot of different uses, but we're kind of excited about, about using.

MEMBER CORRADINI: So the orange, the pink and the green is early RCIC failure or early FLEX failure, at least to a two-thirds to three-quarters of the --

MR. TRUE: Right.

MEMBER CORRADINI: And then of that, I was just trying to understand which of these produce a large source term which would be on the right hand side. It'd be OP and the LMT.

MR. TRUE: Yes. It'd be down here.

MEMBER CORRADINI: Yes.

MR. TRUE: Right, so --

MEMBER CORRADINI: So like a third of them seem to go that way, right?

MR. TRUE: Yes, it looks like there's --

MEMBER CORRADINI: Primarily --

MR. TRUE: Yes. Well, this chunk is going there, right?

MEMBER CORRADINI: Right.

MR. TRUE: And then this chunk is going there. And then some piece here is going on there.

MEMBER CORRADINI: So even the, I mean, I'm just trying to understand. To the extent that I understand the diagram, the flow chart, I mean, the whole diagram, it's a large piece of the combined early RCIC and then small pieces of everything else.

MR. TRUE: Yes, the wire melt cases, yes, yes. And that's partly because that's the largest probability.

MEMBER CORRADINI: What is APET?

MR. TRUE: -- probability.

MEMBER CORRADINI: Remind me again, what's --

MR. TRUE: These are the end states of our unreadable APET.

MEMBER CORRADINI: Okay. But 017 that takes over pressurization, APET 017?

MR. GABOR: 017, I think, is also an in-vessel retention case. APET 017 would be, that's interesting, in-vessel retention going to, I guess it could be if you didn't have a vent.

MR. TRUE: If you didn't have a vent.

MR. GABOR: So it's the core. I mean, I think that path is, the core's in the vessel, but you don't have containment heat removal.

MEMBER CORRADINI: So that's the core that's --

MEMBER STETKAR: That's correct, at least according to the logic.

MEMBER CORRADINI: But I wanted to bring up something. That's Fukushima.

MR. GABOR: In-vessel retention for --

MEMBER CORRADINI: Well, maybe I'm projecting something.

MR. GABOR: Okay.

MEMBER CORRADINI: But that's potentially in-vessel retention. But I still over-pressure it.

MR. GABOR: Yes, yes. No containment heat removal.

MEMBER CORRADINI: So how did I get there again?

MR. TRUE: I didn't get FLEX early, so I got core damage, because I had a short time frame. I was able to use the FLEX capability to inject water later. So I saved the vessel. But my vent didn't open.

MEMBER CORRADINI: Okay.

MR. TRUE: And this --

(Simultaneous speaking.)

MEMBER CORRADINI: Okay, that one looked very similar to something that happened.

MR. TRUE: Well, and the majority of the time, the wetwell vent is working which you'd expect since we've just spent or we're in the process of spending a lot of money for something.

MEMBER CORRADINI: Thank you.

MR. TRUE: Okay. Now it's Jeff's turn.

MEMBER BLEY: One last question before going, I couldn't read the top events in here, but I can read them over here on the APET. But if somebody's doing the HRA for you under some condition occurring out in the APET, there's really nothing in the logic structure that lets them know the status of, say, the instruments, DC power, that sort of thing, is there? I can't see it?

MR. TRUE: No. I carry that through behind the scenes. It's the difference between the way I --

MEMBER BLEY: So you have them, okay, do it with DC power and without DC power.

MR. TRUE: Yes.

MEMBER BLEY: And then you do it end calcs to mix them all together.

MR. TRUE: Yes.

MEMBER BLEY: Okay.

MR. WACHOWIAK: In the spread sheet there's like pseudo fault trees that plug into each of these --

MEMBER BLEY: Okay. But you're tracking the --

MR. WACHOWIAK: And the dependence is going to carry forward.

MR. GABOR: Okay. So as Doug said, we've

got 13 core damage end states, 39 APET end states to give us a total of 507 end states in the containment event tree.

And with 24 possible alternatives that we're modeling between water injection to the RPV, vents, cycling, filters, we end up with over 12,000 individual MAPP runs. And then each one of those MAPP runs feeds an independent WinMACCS calculation to get the offsite consequences.

What, just for your own, my own knowledge, our own knowledge that we're using a Python script that can actually build these input decks based on the shape of both the core damage tree and the APET.

So it knows what every branch looks like. It builds the deck. We run the calc and then generate the kind of automatic transfer, much like MELCOR and WinMACCS, an automatic transfer of the timing of radionuclide release, the different species, time history, some other information combined of course with weather data and population data to calculate the offsite consequences.

We've been doing this by using EPRI's Phoebe computer which is a high powered computing system, 500 and some cores. So that's how we get through all this.

MEMBER CORRADINI: So should I appreciate this as similar to what -- I have no comparison. So is this similar to what the folks do within the staff? Or is this different --

MR. TRUE: They have 41 MELCOR runs --

MR. GABOR: They would bin their end states and then pick representative scenarios. Where we don't have to do that.

MEMBER CORRADINI: But if you were to bin, do you get, other than a lot of gray, do you get about the same binning? And I'm back to the comparison where I asked you a comparison about this to this.

I'm curious, if you took your 1,224 times 507 and I looked at this and how I binned it, would it kind of look the same? Or do you have some strange outriders in relation to what --

MR. GABOR: I think our end states, I think the definition of the end states, because our core damage trees are similar, our APETs are similar, our end states are similar, how they've been, we haven't seen that documented yet. So how they actually binned those end states into the 40, we haven't reviewed that yet.

MEMBER CORRADINI: Okay. And so the next question is since this is so automated, when you push the button, how long does it take before 12,000 and something pop out?

MR. GABOR: The brains of the operation, David Luxat, who works with us can tell you exactly. But I believe that, on the MAPP side, you're talking about maybe three days, four days to crank that out. WinMACCS is running about the same time for us as well, so another three or four days --

MR. GABOR: To do 12,000 cases?

MEMBER CORRADINI: Yes.

(Off the record comments.)

MR. GABOR: So the challenge, of course the challenge with this is then how do we review and how do I communicate the results of 12,000 calculations, a true challenge.

And we've been experimenting with a lot of different things. I don't have the flashy Sankey plot like Doug has, and we may eventually get to that point, but what we've tried to do is, first thing I did was to try to identify what parameters am I most interested in.

And what I came up with, we talked earlier about a DF, a surrogate for releases. And we've got a way to look at that. The other thing that's of interest to us is hydrogen control and the impact that these strategies have on hydrogen control throughout containment and primarily out of containment into the reactor building which is where it can do the harm.

And then thirdly, we had an interest, primarily because of the work being done on the vent order, to look at temperatures in containment. We know that the temperatures in containment affect the type of vent valve that we put in the plant. So we focused on that. So I picked those threes as kind of the first ones to look at.

What I'm looking at here is, for the alternative case where we had severe accident water addition, we wanted to look at, if I had the water or I don't have the water, what's the impact on, in this case, the maximum drywell cylinder temperature?

I picked that because that's in the cylindrical part of the drywell which is most likely where the drywell vent valve would be located. So what I'm looking at is just kind of go or no go on whether the water is being injected in the containment or not.

And if you look on the left this is a

cumulative probability plot. And you can kind of come over here, and you can see that by the time I get to, you know, pick a number, 90 percent, 90 percent of the probability yields a temperature, I'll pick a number, 550 degrees or something like that, and then you can see that there is a tail that actually maxes out up here around 630 degrees or something like that, 650.

One thing that Hossein showed today were structural temperatures. We have those. Unfortunately, I didn't plot those here. So there is a lag, a considerable lag between the actual, where the valve temperature compared to the gas temperature.

We see things in some of our calculations like high pressure melt ejection scenarios. Obviously, out of these 507 end states, there are some of them, if you go back to Doug's tree, that resulted in a high pressure melt ejection.

Those cases, we tend to see spikes in temperatures. Now, a spike in the gas temperature isn't going to take out our drywell valve. But they do tend to get us up here on the tail of the distribution.

If I compare that kind of 90 percentile at 550 degrees, you know, you can almost see 100 percent of the cases are less than 600 which is very consistent with what the MELCOR results were presented earlier today.

Probably not a revelation to anybody, but if I don't have water that distribution doesn't look good at all. You know, my 90 percent now says I'm above 1,100 degrees.

MEMBER STETKAR: Now, is this water addition into the vessel or into the containment?

MR. GABOR: Good question.

MEMBER CORRADINI: To ease vessel.

MEMBER STETKAR: To ease vessel.

MR. GABOR: Yes. And I'm glad you asked that. But --

(Simultaneous speaking.)

CHAIRMAN SCHULTZ: Can we go back?

MR. GABOR: Yes.

CHAIRMAN SCHULTZ: You mentioned in the first display, the blue one, that some of the information was spike behavior. And does that same comment apply in a different way to the next scope of the drywell?

MR. GABOR: To this one?

CHAIRMAN SCHULTZ: Yes, would --

MR. GABOR: It does, but without water it's a different response. Yes, there could be some of those. But without water, with the core on the drywell floor, temperatures of 1,000 to 1,200 are expected, yes.

CHAIRMAN SCHULTZ: Yes, anyway.

MR. GABOR: Yes. Again, we're still kind of feeling our way through these, how to best --

CHAIRMAN SCHULTZ: Because it's an interesting case. But what Steve was describing before, you've got quite a range of potential design temperatures that one might choose. And the high temperatures are very high --

MR. GABOR: Yes --

CHAIRMAN SCHULTZ: -- compared to 1,000 degrees.

MR. GABOR: I don't, I personally don't view this as a viable strategy to not pull water in.

The next one is looking at the impact of water addition. And again, I believe we saw or at least heard some of this this morning, is whether or not I inject it into the RPV or if I inject it directly into the drywell.

Our cases, and I think we talked about this before, when we say drywell injection, it really isn't taking any credit for drywell sprays. We're not benefitting from any kind of thermal interaction between the spray droplets and the atmosphere.

We're just saying you're getting that 500 gpm to the floor. So it's only seeing the debris, and it's impacting the temperature through its ability to cool the debris or at least cover the debris with water.

So if I just take, if I now look at two of my alternatives, and 2E was, as we just said, was RPV injection, the same strategy, the only difference being what if I put the water on the drywell floor. That's the red distribution.

And in this case, I'm assuming that water always succeeds. Remember in our containment event tree, we actually do have, even though we provide the means to have water by the alternative, there's a probability it's going to fail. So some of those branch points in our event tree are failure of water.

Well, I don't care about those. I don't want to look at those. I know they're going to give me high temperatures from the plot before. So I'm looking at cases where that water was successful. And I'm also looking at cases where I'm drywell venting.

And I have couple ways to drywell vent.

And I think we talked about it earlier, that the normal procedural guidance is I start venting my wetwell. If I'm putting water into containment and the level goes up in the torus, at some point the operators are told to isolate the wetwell vent. They don't want to flood it out.

When the pressure continues up, the next time they have to vent they're going to have to use the drywell vent. So we're looking at cases where drywell venting was implemented. And all I'm trying to do is to provide the order people with some idea of what kind of temperature should you expect to see.

And independent of where the water's going, again, they've actually, as was mentioned earlier, they have been working with the staff on establishing a design temperature and have come up with the 545 degrees. If I come over here and I look at where is 545, I'm 95 percent of all of the probability of the end states will be 545 or less.

So again, for the vent order for the EA-12 13-109 folks, 13-109, it gives them some confidence that that 545 number is pretty good, pretty good guideline. Yes, there's a tail out here. Again, there're some of these high pressure cases that might punch above 545. But, you know, being able to claim 95 percent of all of the risk is helpful.

MEMBER BLEY: This is a non-technical --

MR. GABOR: What's that?

MEMBER BLEY: I was going to say, this is a non-technical comment. But since these are distribution functions, you shouldn't have those vertical lines on the right side.

MR. GABOR: You're right.

MEMBER BLEY: And it drives me nuts.

(Laughter.)

MR. WACHOWIAK: The reason that it's there is it indicates the highest temperature that was seen in --

MEMBER BLEY: Okay. So put a little dash line down there --

(Simultaneous speaking.)

MR. WACHOWIAK: Yes. But that was, even if the probability of that branch was zero, it'll still show that one. But you could see that those are all on very, very small probability cases so --

MR. GABOR: We'll work on the dotted line.

MR. WACHOWIAK: We'll work on that.

CHAIRMAN SCHULTZ: One more question, and this is, if you will, historical. You've got a display here that really provides additional justification of the 545 degree Fahrenheit. And that number was selected some time ago, but could you just rehearse what the basis of the 545 choice was originally and how this is --

MR. GABOR: There was a couple of pieces. And we may have to lean on Phil Amway to fill in some gaps. But the initial temperature, if you recall I think we, at some point we may have shared it with you. We looked at, for all severe accident types, and we looked at the kind of expected, we looked at SOARACA, the expected temperatures of when the containment might start to leak.

We looked at all the Sandia test information on seal, containment seals, and the head and penetration leakage. And what you get out of looking at that, and this is kind of from my phenomenological perspective, is you see, from all that data, that starting at around 500 degrees there starts to become some probability that you're going see leaking.

And that seemed to increase between 500 to 700. Above 700, I think it starts to increase a little faster. And by the time you get to 900, I think it was the CB&I work they did to support Mark Is, they say there's no pressure capacity of the capability to containment anymore. So we've got this distribution that seems to start around 500, extends all the way up to 900.

The owners came together and found that they had a referenceable point in space which was the 545. And it's actually the temperature that the PCPL curve is evaluated at.

If I understand it, and he's going to correct me, it's simply the maximum temperature that the containment could reach in a non-severe accident where the RPV is at 2,000, or 1,000 pounds. And that's saturated at 555 or 545, whatever.

MR. AMWAY: This is Phil Amway, Exelon Corporation. And Jeff is exactly right. In the initial assessment of where we were going to try to pick this design temperature, it was based on the PCPL calculation.

The rationale for it is containment design pressure, PCPL, was what the vent order was designed to protect. So we looked at that calculation. The range of temperatures assumed in that calculation was anywhere between 100 and 545 degrees Fahrenheit. And so we chose that maximum temperature.

CHAIRMAN SCHULTZ: That's good. So now we see that this is a looking at it from a different perspective and coming to the same conclusion. Thank you.

MR. GABOR: The next thing I wanted to look at, and again, we're still trying to find the best way to package this. And I'm sure there's going to be a lot more out there. I wanted to look at hydrogen in the reactor building to see if there was some insight gained there, probably not, again, not too earth-shattering.

I took, again, a case, and this one it's injecting into the RPV. But I just wanted to see the impact of the peak hydrogen concentrations in the reactor building. Because we all know Fukushima, it's what caused the problems in the RB and the hydrogen explosions.

I just wanted to kind of look for all of these scenarios, all these 507 scenarios for this alternative. Which ones, how were they affected by water injection or no water injection?

And again, if I put water on the debris

in the containment, I've got a, pick a number, 95 percent chance that I'm going to have zero hydrogen in the building, only makes sense. And there is a tail there, because there's some end states where we do get some leakage out of the drywell head into the reactor building.

But the counter to that is, if I don't put water in containment, I'm pretty much assured that I'm going to leak hydrogen into the reactor building. One way or the other, it's going leak in there. High temperatures are going to cause that.

And in fact, there's, you know, I'm always going to see hydrogen concentrations in the, whatever that is, six, seven, eight percent range. And by the time I get to 50 percent -- and these are a little misleading. We talked about this quite a bit yesterday in the public meeting.

And we're going to look at better ways maybe to show this. This is actually a peak concentration in the reactor building. In certain control volumes in the reactor building, that could actually be steam-inerted. So that's how I'm getting these concentrations greater than eight percent. Because if I wasn't steam-inerted, it would be limited to, you know, just normal combustion limits.

So there are rooms, there are compartments in the reactor building where I was, for a brief period of time, steam-inerted. And that allowed me to accumulate a higher concentration.

That's really not the point I was trying to make. It's really between that data point there that says, if I put water in, I'm unlikely to get hydrogen in the building. And in this case, if I don't put water in it's pretty much guaranteed.

Again, still looking for ways to get the word out. Okay, so we spent some time, the NRC folks spent some time this morning talking about decontamination factors.

The first thing I guess I would say about decontamination factor is I don't necessarily view it to be the best performance measure. Because obviously it is, I think, Joy mentioned earlier that there's no time-dependence by just looking at that.

You don't know what was released early, what was released late. You just know that, integrated over the 72 hour period, the integrated performance of the containment yielded a certain decontamination factor.

And in fact, in some of the early consequence work that we started doing, we found that, even down to overall integrated DFs of 100, that we were approaching some de minimis behavior as far as looking at offsite consequences.

So picking a hard number I don't believe is where we want to be. What I did hear is I picked a number, I picked 1,000, only as a way to, again, do a relative comparison. And I did it on this one, and I did it on the next chart.

This chart I was simply trying to look at the benefit of water management. Remember, we've always got water addition. We have an option, an alternative that says, okay, you can turn the 500 gpm on and walk away, just let it go.

It's going to flood the torus, the operators are going to follow their procedures, they're going to close the wetwell vent. And then later they'll vent through the drywell. So that's kind of what we have today.

On the other hand, if you realize that you really don't have to put four feet of water on the floor to be effective, that you can maybe maintain a foot, or a half a foot or some nominal amount of water on the debris, you can get yourself into a kind of quasi-steady situation where you've got the wetwell vent open, you're venting off steam, and you're putting water on the debris.

And the torus is held constant and you've preserved, the whole point of water management is to preserve the wetwell vent. Why would we do that? Because it's scrubbed. Even if the pool's saturated, it still provides some scrubbing.

So all I did here is I picked this kind of fictitious cutoff of 1,000 isn't my DF or a cesium release of a tenth of one percent. And I said what's the impact on water management versus no water management?

So what I'm showing in the pie here is that 91.2 percent of the cases have DFs greater than 1,000 of the total, this is all frequency rated, 8.8 percent had DFs less than 1,000.

Without water management, that number of the split changes just a little bit. And it's kind of what I expect. Because with water management, I don't open the drywell vent. In no water management, I'm going to open the drywell vent later.

Now, what we saw in the EPRI filtering

strategy report is that opening a drywell vent late didn't really have a huge consequence impact. Source terms went up slightly. But you're talking about opening the drywell vent two, three days into the accident.

The aerosols have fallen out, you've benefitted from time and scrubbing, all the passive scrubbing mechanisms, and the source term isn't that largely affected. So you can see it goes from 8.8 to 20.

I should have just got rid of the decimal points, I guess. Because I surely don't believe those but, you know, ten, 20, about double. And it's just because of that.

The other thing that's very interesting in this, and we talked about it yesterday in the public meeting and we were able to go back and take a look at, for example, if I look at the no water management pie here, I say that 79.7 percent of the risk is coming, it has a DF greater than 1,000, and 20 percent has DFs less.

Keep in mind when I draw a hard line in this function, I could have a DF of 999, and it's going to fall into that green slice. But what we found is

80 percent of just looking at the end states that contributed to this green portion, meaning the DF less than 1,000, 80 percent of our end states actually fell into that pie.

Twenty percent were in this. So what that tells everybody, you probably already know this, but what that tells me is that you really, truly have to focus on the dominant scenario. You can't just put a bunch of source terms up on a chart without frequency-weighting them. You've got to bring it all together.

Obviously we, both the NRC and the industry, will do that as part of the consequence analysis. That's what a Level 3 does. But I'm trying to kind of bring that way of looking at source term results forward as well.

CHAIRMAN SCHULTZ: And so this is the frequency weighted --

MR. GABOR: Right.

CHAIRMAN SCHULTZ: -- presentation of the end states. It's not --

MR. GABOR: Yes, and if I --

CHAIRMAN SCHULTZ: It's not all the end states --

MR. GABOR: Right. It's an Instagram.

CHAIRMAN SCHULTZ: It's a portion of the end states.

MR. GABOR: Like Rick said, if we plotted this --

CHAIRMAN SCHULTZ: You wouldn't call it risk related, risk of the event.

MR. GABOR: Yes.

CHAIRMAN SCHULTZ: So the plausibility.

MEMBER CORRADINI: Can I say it again? Because you caught it. But maybe I didn't get it. The 80 percent, the blue versus the green, that blue is an integrated DF over -- is it the peak DF? Is it integrated yet?

MR. GABOR: No. It's the probability of the event. It's a sum of the probability of the end states that resulted in a DF greater than 1,000. So I just summed up all, you know, the 507, I broke it into two bins. It's either greater than DF of 1,000 or less than 1,000.

MEMBER CORRADINI: Then you multiplied by --

MR. GABOR: Nothing. I just added the frequencies.

MEMBER CORRADINI: Oh.

MR. GABOR: That's all. I just summed the frequencies.

MEMBER CORRADINI: Okay, okay. I'm with you. But I'm back to the DF part, I'm sorry. I'm back there. When you say DF though, it's still a time limit where it's --

MR. GABOR: Yes, sir.

MEMBER CORRADINI: -- accumulated of what that, over some time period. And that time period was what?

MR. GABOR: Seventy-two hours.

MEMBER REMPE: So the staff presented cesium release and gave us an argument today about that things are sort of the same range. When you compared, did you compare your integrated cesium release with those? And was it sort of in the same range?

MR. GABOR: We looked at a couple cases, very tough to do. Because, again, we're just now seeing no result. We're trying to match, you know, some of those scenarios with the corresponding case that we had.

I looked at one last night, a very particular one that actually they happened to include in their package. And it's for a case I recall where RCIC had run for a long period of time, 16 hours. The pool gets saturated, then the vent containment and all that.

I think their calc had a DF in the range of 300. We were very similar to that, 270. So they were pretty close. We have seen other cases, much like we're doing with the cross-walk, where we are focusing on some of the difference between MAPP and MELCOR in the in-vessel phase. We can see some of those differences translate to the DFs, to the cesium releases. And we're in the process of looking at that a little deeper.

MEMBER CORRADINI: I'm not sure, I think I know what you just said, but I'm not sure. So can I say it back at you? Are you telling me that whatever I calculate in the simulation in-vessel and it then that gets translated ex-vessel, that history matters as to what eventually is released in the substrate?

MR. GABOR: Yes.

MEMBER CORRADINI: Which is the original reason that the crosswalk was done back in October of almost a year ago, right?

MR. GABOR: But our focus on the crosswalk is more the core melt progression, and the timing and not the source term.

MEMBER CORRADINI: Right. But the only reason, I guess the only reason I would want to do it is if it matters. And it matters if it matters --

MR. WACHOWIAK: But we just need to recognize that this is preliminary. We haven't seen, we've seen the charts that have the dots and the DFs. But we don't know how to connect those back to all the different cases just yet.

MR. GABOR: Right.

MR. WACHOWIAK: So we looked for awhile for cases that we thought we could find in our set that were the same in your set. We found the one which was a, you know, lower than 1,000 DF. And it's in one of our lower probability cases.

We found another one, there was a main steam line break that we were able to compare with very low DFs. But in the blue bar, we couldn't identify, from the material that we had in the package, a case to compare there just yet. So we still have more work to do.

CHAIRMAN SCHULTZ: What was the extent? Can you describe the intent and the extent of the crosswalk?

MR. WACHOWIAK: There have been, over the years, many MAPP and MELCOR comparisons. And many times if someone says, okay, I want to compare these, and they go out and they do a comparison on some accident, and they get just completely different results.

When we dig into why there's completely different results, most of the time it's because they didn't all hold the same boundary conditions. Okay, those are easy to take care of. But other times, it appears that the same boundary conditions were modeled, but you still have different results.

And when we go back to the experiments that were used to validate MAPP and MELCOR, they're the same set of experiments. And they both validate MAPP and MELCOR. So something is different between the experiment and the severe accident simulation.

So the intent of the crosswalk was to bring the developers of the two codes together, get them in the same room, moderated by an impartial member, but to talk about this.

Okay, so when you saw this in the experiment, how did you turn that into code? What kind of assumptions were you thinking, what kind of decisions were you making to turn the experimental data into the code that we have?

And what we were looking for there were differences between the mindsets of the two different groups on how they did that. And we found a couple of places where the decision about how to handle a numerical problem drives some of the answers, like gas temperatures in the reactor vessel.

And, you know, it was mainly associated with how do you deal with the problem of approaching the caught limit or flow through a degraded core. MELCOR decided to do it one way by limiting the flow degradation. MAPP did it another way by saying if the flow was blocked too much you're not going to get anything through it.

Both valid assumptions, both match the experiments, but when you put them into these sorts of things, it makes a difference.

So we wanted to try to understand that so that when people are monitoring these things you'd either, one, know that you maybe have to make some different boundary condition decisions because of the way the implementation was done in the code, so maybe it looks like it's the same boundary condition but to make it the same for the two codes you have to do something slightly different, or just recognize that they're going to be different in these cases and you should expect to see those differences in the results.

Phase 1 of the crosswalk that we got through got up to from the onset of the accident to the core slump to the core plate. At that point, the reference calculations that we did had diverged enough that we needed to go back and reset the assumption so that they were closer together at that point so we could look at what was going on in the lower plenum.

Current status of this now is that was completed. We've gathered all the notes, and we're writing the report for Phase 1. And we're looking to see if somebody's willing to fund Sandia to do the next phase.

MEMBER REMPE: So when you just talk about differences with the BWR, there're some fundamentals in the modeling, MAPP versus MELCOR, that make it so you would expect more differences in timing, just because of the approach that was taken. And so that's why I'm asking a lot of questions about the differences.

MR. WACHOWIAK: Yes. And what we found

in that first one through it was almost all the differences can be attributed to that one assumption.

MEMBER STETKAR: Interesting, thank you.

MR. GABOR: You know, I guess I'll just pile it on a little bit that ultimately we want to, we'd like to make sure that our strategies are robust enough so that they're not dependent on those kinds of variations.

And one of the things we all heard last week, the industry had a large group along with Dr. Fuller from the NRC. We went out and we spent a day or half a day at Argonne to understand some of the debris cooling experiments that Mitch Farmer has been running.

And interesting in his work, in his analytical work, he's actually taken the output from MELCOR, he's taken the output from MAPP, and he's done parallel calculations.

And with a few minor differences, his conclusions are independent, are robust enough that, yes, independent of those two different ways of looking at things, putting water on the debris does result in debris cooling. He still sees the same phenomenon occur in terms of eruptions and particle bed formation.

So again, ultimately we want to make sure that there are going to be some uncertainties. We want to make sure our strategies are robust enough to cope with those.

CHAIRMAN SCHULTZ: That's an important addition, Jeff. I appreciate you adding it. Thank you.

MR. GABOR: The last slide I have, at least for this part, again, not to try to make any kind of a performance criteria determination or success criteria that says need a DF of 1,000, or 100 or whatever, I just used 1,000 as a way to look across all of our alternatives to just start to look at some of the trends. I want to see is one alternative relatively better than another one.

On the left side you see, just as the NRC presented, you see the two cases, the baseline and Alt1A, which are cases where I do not put water in containment. In those cases, you see that almost all of the time my DFs are less than 1,000.

If I start looking at the alternatives like 2A, and 2B and 2C, I'm putting water in containment. Now, in 2B I'm doing water management. In 2C I think I'm cycling the vent. You only see minor perturbations, really, from those things.

And I can take you all the way out to the right here where I start looking at filters. Remember in Doug's chart, four and five were cases where we had, four was a small filter, five was as larger filter. A and B are RPV injection and drywell injection.

Again, you do you see a reduction, and you do see there is some benefit if I compare, for example, 4A and 2A, or 4A and, I guess, 2E might be better. You see there is a reduction in the number of cases that have DFs less than 1,000. But it's not night and day.

And you've seen these charts from us. Doug will show you more. The benefit we see is in severe accident water addition. And the rest of the variations just don't jump out at us as providing that much more added benefit from a perspective of looking at a DF.

And you're going to see the similar, once the cost benefit's done, you'll see this translated to cancer fatalities, and cost numbers and things like that. But this is my view of it at the kind of source term level.

MR. WACHOWIAK: And one thing to point out here, the previous slide had Alternative 2E with the pie chart. And this one has alternative 2E. And you can see the split is different there. That's not eight percent or nine percent that we had before.

The previous one had disregarded, the pie charts had disregarded all the liner melt-through cases. Because they're not, they weren't interesting from that point of view. Because none of the cases that had liner melt-through have really much potential for mitigation. So in the pie chart, we subtract an amount here, and it's all included in liner melt-through along with everything else.

CHAIRMAN SCHULTZ: All right. Jeff, I'd like to call for a break at this point. I'm going to be generous and have a call back at 3:30 with the intention that that will give us enough rest so we can charge forward. So I'll call it a recess. Thank you.

(Whereupon, the above-entitled matter went off the record at 3:13 p.m. and resumed at 3:29 p.m.)

CHAIRMAN SCHULTZ: We're back in session. And Doug just now announced that he will be the next speaker. So we will call upon you to begin. Thank you, Doug.

MR. TRUE: Okay we're going to tag team. I'm going to back and just do a little fly by on some of our results. And we're going to do our best to get you back on approximate schedule.

CHAIRMAN SCHULTZ: It's on time, thank you.

MR. TRUE: So we're going to talk about results. Presenting some information that we presented in our June 18th public meeting, unfortunately, it's got a different numbering scheme, and it's part of this one.

MEMBER STETKAR: You know, after you get so that you're just intimately familiar with every number, you change it on us.

MR. TRUE: Yes, well, backwards unfortunately. Well, the issue with these results is that they're done for a limited MACCS deck that isn't the same as the one I want to use in the end. And we just recently got the SOARCA decks, and we're trying to incorporate those.

So I'm going to present all of those in relative terms, not in absolute terms, just because they're going to change. And I didn't want to be misrepresenting results.

So I want to look at kind of four aspects of this, five, four or five, any way you want to look at it, some conditional containment failure probability and what the alternatives look like from that perspective, margins in the safety goals.

The max averted cost risk which is, you know, given that we have a core damage condition we're looking at, what's the max averted cost associated with that set of scenarios with different alternatives?

So as you implement an alternative that reduces that max averted cost, you're actually generating a benefit that goes into the cost benefit calculation. So -- condition with containment failure to probability, the base case on the left is the pre-alternative, sort of the ongoing end case.

FLEX is implemented but not severe accident capable. Jeff already kind of showed this, that the majority of the time it leads to containment failure. And then across the different alternatives, we're getting an answer for our results, for our calculation of failures and reliability of about a 70 percent reduction in containment failure probability. And that's all primarily driven by the water. So this notion of benefit of the water protecting containment, you know, is really shown here as much as any other slide that we're going to present.

MEMBER CORRADINI: And so containment failure is defined in this case as essentially an uncontrollable release?

MR. TRUE: Correct. So the over-pressure failure, the amount that are vented, the containment's still intact. But that was open intentionally.

MEMBER CORRADINI: It could be an over-temperature --

MR. TRUE: Could be an over-temperature failure too. It'd be a failure.

MEMBER CORRADINI: Okay, thank you.

MR. TRUE: If you look at this from the standpoint of relative event change in latent cancer and relative fatality risk, this isn't compared to the safety goal but just gives you a sense of its relative scale. We get an awfully similar view that, you know, we're getting a substantial reduction by putting water in by whatever means.

The filter's, though, a little bit beneficial. And Jeff kind of showed this in his results as compared to the no filter cases. But it's a relatively modest change in the overall view of the risk. And that's because the dominant contributors to these risks are the bypass scenarios which bypass the filter.

This one's a little bit on the filter itself. And we have the specification where we looked at a base case with a filter without any water addition just to reinforce the point that without water a filter doesn't really help you that much.

If you put water and a filter in, which are the two right hand bars, then you're going to see that more substantial improvement. The middle bar, the three Alpha bar, is the case without a filter. And then the four and five are, that's in a case with a small filter. It's just needed in a small capacity. And the five cases were the large filter.

MEMBER BROWN: What does MU mean?

MR. TRUE: Make up and its addition. And before we talk about SAWA so --

MEMBER BROWN: SAWA.

MEMBER CORRADINI: And when you start at WA you're in MU?

MR. TRUE: Yes.

MEMBER BROWN: Make up is different kind of water?

MR. TRUE: No. It's the same. It's just a different --

(Simultaneous speaking.)

MR. TRUE: The vintage of the slides --

MEMBER BROWN: Maximum confusion.

MR. TRUE: Yes. I don't really remember we renamed, but --

MEMBER STETKAR: And with this slide you were warned.

MR. TRUE: Like I said, the numbering scheme --

(Simultaneous speaking.)

MEMBER SKILLMAN: Why is the difference between large and small filter so small?

MR. TRUE: Because the way that EOPs are set up is that you preferentially open the wetwell vent first which scrubs the water in the fission products into the pool. So the fact we have a small filter doesn't really come into play in the majority of scenarios.

The only scenarios where a large filter has been efficient was if you're preferentially opening the drywell vent first. And then you need a larger capacity to be able to get, capture all those fission products in the filter.

So in my analysis, when the wetwell vent is available, the operators will use it. So the only cases where the large filter has a play is when the wetwell vent failed to open and they wanted to open the drywell vent first as a means to --

MEMBER SKILLMAN: Okay, thank you.

MR. TRUE: -- control pressure.

MEMBER SKILLMAN: Thanks.

CONSULTANT SHACK: In the previous slide, the different cases aren't the smallest.

MR. TRUE: Yes, right. This was a little bit of a surprise. And the difference for that is, as I pointed out, is that we're given benefit from industrial retention.

In the RPV injection case, we keep the vessel intact which means we reduce the containment challenge associated with the debris getting into the drywell and then having to be quenched at that point. Even though a filter, it filters most of those, where preserving that water or additional fission product barrier.

MR. GABOR: Yes, the filter cases had the water addition going into the drywell.

MR. TRUE: Well, not really. The operator actions that went into these were assumed to be basically the same, because it's the same water, we're assuming it's the same water connection. It's just a matter of whether that hose is going to the drywell or going to the RPV. So it's totally a --

MEMBER BLEY: Not quite the image, but okay. So it was okay.

MR. TRUE: So it was okay.

MALE PARTICIPANT: Two hoses.

MR. KRAFT: Well, it's severe accident capable hoses. Severe accident, yes --

MALE PARTICIPANT: Really good hose.

(Simultaneous speaking.)

MR. KRAFT: And outside the plant, the valving is the hosing he talked about. I just want to, they're not running any containment. They're hooking up hoses, is my point.

MR. TRUE: No, we're not.

MR. KRAFT: I just wanted to make that --

MR. TRUE: Sorry.

MR. KRAFT: There you go.

MR. TRUE: Marty showed one of these before. And this is going, I should have just gone forward when you asked the question. But do we invest, is the big difference in the two Alpha? So in the R.V.

injection cases we're seeing two benefits. Jeff pointed one of them out, I think, earlier and I think the NRC cited them too. One is the temperature benefit. It's a small temperature benefit. Because we're cooling the RPV which is the main heat source once the core debris is quenched. But the other is retaining the debris in-vessel then preserves the containment down to the --

MEMBER CORRADINI: How do you, in a B, well, maybe I don't understand the geometry. How are you retaining in-vessel? We're talking in-core or in the lower plenum?

MR. WACHOWIAK: Lower head.

(Simultaneous speaking.)

MR. TRUE: Before a slump, right?

MR. WACHOWIAK: Yes, it could have still slumped though. Most of it still needs to be in the core region. So it's in that intermediate area.

MEMBER CORRADINI: So it's kind of hither, thither. Some here, some there.

MR. WACHOWIAK: Yes. But still inside, because you --

MEMBER CORRADINI: But it's nothing like an external source of cooling. It is still internal cooling --

MR. WACHOWIAK: Yes.

MEMBER CORRADINI: -- and you're continually adding water and blowing it off.

MR. WACHOWIAK: Yes.

MR. TRUE: Yes.

MEMBER CORRADINI: To the leak?

MR. WACHOWIAK: So there's a limit to when that's good. If you put too much in the lower head, it, well --

MEMBER CORRADINI: Okay.

MR. GABOR: But our event tree --

MEMBER CORRADINI: I understand, but --

MR. GABOR: Our event tree has to, you have to have the water, you have to have the depressurization. And then even if you have that, there's a likelihood it doesn't succeed.

MR. TRUE: And when you get the water on it, it'll come out, still come out of the vessel. And that's accounted for in the --

MEMBER BROWN: So if I read these graphs, the last ones you did last few you've done, sends the message that you've got to put water in the drywell? And I don't know what VC is.

MR. TRUE: You've got it right, because it reduces the debris.

(Simultaneous speaking.)

MR. TRUE: -- in wiring, so it's debris in vessel. Very little.

MALE PARTICIPANT: It doesn't stay in the vessel, people.

MR. TRUE: But that's not what that says. It says ten percent. The core, oh, the relocation. But I thought that --

MALE PARTICIPANT: Yes. And the core debris is in-vessel and --

(Simultaneous speaking.)

MALE PARTICIPANT: And the bigger green is good.

(Off the record comments.)

MALE PARTICIPANT: Debris in the wrong place.

MEMBER CORRADINI: No, no. Just the opposite.

MALE PARTICIPANT: That's a big boiler, core debris location.

MR. GABOR: We want to retain it in the vessel.

MEMBER BROWN: Is that good?

MR. GABOR: Yes.

(Simultaneous speaking.)

MR. WACHOWIAK: Smaller red, smaller blue is good.

MALE PARTICIPANT: After awhile, it's a long time ago.

MR. TRUE: This again is on a real relative basis, the MACR, the maximum averted cost risk which is we start out with a base case that has a certain set of consequences associated with it, like cleanup, onsite cleanup, exposures, those kind of things.

And then as we do an alternative, we reduce that impact by reducing the consequences of the scenarios. And they're just plotted here on a relative basis, similar trend to what we found on all the others. The big benefit is getting the water into the --

CONSULTANT SHACK: So watering the vessel's still a good idea.

MR. TRUE: Watering is good, in the vessel is good. And we work these cases, just to be clear, the four and five are comparable only to this 3 Alpha which is drywell. Because we only put it in the drywell thinking as, as we went into this drywell, for any time we have containment we'll put the water in the drywell and put a fence around the drywell.

So if we get a case where we have R.V. make up with a sensor, you'd see your comparable bar to the 2 Alpha case over here. Looks like, you know, a little bit lower than the 2 Alpha, but it's not already made. And we have those cases in our new numbering scheme.

So sensitivities, we've identified the set, we're still working through exactly which cases we're going randomly add to this, including looking at some variability across the fleet.

We're going to do probabilistic and some phenomenological or MAPP, MACCS kind of calculations. The check marks are the probabilistic ones. So they're in some ways sort of the easier ones to do. Because we just go in and manipulate the probabilities.

And the ones with those checkered things, those are ones where I imagine Jeff's got to go back and rerun the MAPP and MACCS ones. So we're looking at the ELAP frequency, there's variability across the fleet in that. We're going to see how sensitive that is. It's pretty much a linear relationship, so it's straightforward. FLEX equipment reliability, if we make flexibility more reliable, how much benefit do we get out of that.

Then I looked specifically at some of the key human error rates, whether it's the FLEX deployment, or the water injection, the water addition, reliability, water management and reliability and then vent control reliability. So we understand how sensitive our results are to making those factions reliable.

In the vent control pressure band, we're using a control volume of 40 to 20 psi range for all of the 60 pound maximum pressure. We are looking, if we lower that a little bit, it'll lower the driving force for leakage from containment to see if that changes our overall performance or not.

Chronologically, the MSLV rupture, we saw some of the MELCOR results. And the MAPP shows similar trends. That means the amount of rupture is the important contributor.

We're looking probabilistically. If we change those likelihoods, how does that change our view of the different strategies in vessel retention? You know, what if we're not as good at retaining in-vessel, how does that change our perspective?

The way that we're trying to show failure, in our base case we worked, we didn't use the, basically a SOARCA model for the debris spread of a minor attack.

And the current MELCOR model has changed some of the core debris parameters from that. And so we have, here's one of the differences. We're going to see if we change to a result more like MELCOR's calculating, if we see similar results to what the MELCOR results are. We just wanted to see if we can narrow that gap.

On the Marl II, and Jeff will talk about Mark IIs, we're going to look a little bit at the, especially the bypass issue, see what the results look like with and without that bypass.

And then on the benefit side, there's some typical sensitivities are done on dollars per person-rem and discount rate. That'll all be used to feed the cost benefit evaluation that NEI wants to do.

So, Joy, this would be a good time for you to ask about other sensitivities.

MEMBER REMPE: So we're --

(Laughter.)

MR. TRUE: So we're doing a, we're probabilistic about sensitivities on how likely the main steam line rupture is versus SRV seizure. That's another key phenomenological problem.

And vessel retention is another form of, as Jeff said, with the water and the probability that we're going to retain it in-vessel, what if we're wrong about that? Does that change our perspective on the benefits of an alternative?

The way the drywell shelf, this has to do with flowing debris over the drywell shelf under different circumstances. Using the primary ones, I would say we're going to look at, the Mark I is more physical, Mark II, when we have a physical change to the facility.

CONSULTANT SHACK: The in-vessel retention isn't a capsulated quantity, that's some --

MR. GABOR: The results are, the exact, you know, obviously we know if we depressurize, and we know if we turn a pump on and what its flow is, but as the geometry of the core is changing and our ability to extract the heat from it, there's uncertainties associated with that.

CONSULTANT SHACK: I mean, do you calculate that in math, or you somehow just assign probabilities to it?

MR. TRUE: Assign a probability.

MR. GABOR: Well, the code does calculate whether it's successful.

MR. TRUE: In whether it's successful or not.

MR. GABOR: Right.

MR. TRUE: But we'll have a probability that it was not successful, because of the timing issue and otherwise.

(Simultaneous speaking.)

MR. TRUE: -- this is that, I'm sorry, Joy. But the thought on this is, you know, the vessel failed all the time. We're still getting the temperature benefit of putting the water into the R.V.

So we've been optimistic in one way or another in thinking about in-vessel retention. It's going to still be a preferred option, because it's going to give us the temperature back. That's what I would expect to see. Because they're becoming an awful lot like the drywell water addition, if we're just putting water in the vessel and it's flowing right through and going out into the drywell.

MEMBER REMPE: You're assuming, are you using your vessel failure model or are you using the vessel and a penetration and let whichever one wins win?

MR. GABOR: That's the way MAPP is set up.

MEMBER REMPE: Right, okay. But if MELCOR just has the vessel failure, then they were talking about doing something with the penetration.

MR. WACHOWIAK: And we have ways, in MAPP that you can make in-vessel retention more likely in a scenario versus less likely. And that is a known uncertainty with, you know, how much credit can you get for gap cooling and things like that?

So we're letting it be handled by the probability split fraction in the event tree for it to calculate the consequences of the in-vessel retention. We're adjusting the parameters so that, for that particular calculation, we get the in-vessel retention regardless of the timing. It's a way of dealing with the uncertainties in that.

If we actually wanted to go through and calculate what is the real probability of in-vessel retention, we could do all sorts of different studies. But in the end, you would still make your MAPP run, give you in-vessel retention, and then you'd adjust the probability to get the right split fraction.

But if one gives it to you and one doesn't, you'd adjust the split fraction. So it's kind of, it's a simplification of how we would get there. But it is highly uncertain. You know, you've got to catch it before you get way too much material in the lower plenum. Gap cooling just won't continue to work.

MEMBER BROWN: To the uninitiated, in all this high level stuff that you're talking about, the graphs, and if it's bar graphs that you -- this time I understand the bar graphs. Lower is better.

And if you go back to Slide 35, 36, those two, it would appear if you did nothing but add water to the wetwell, RPV, but then you ought to stop right there, because there's no benefit to anything else. Little if any benefit other than spending money for not much result. Is that a valid, did I get that this time?

MR. TRUE: You did.

CHAIRMAN SCHULTZ: Do you want to go back to flow bars, Chuck?

MR. WACHOWIAK: That was one of the insights that we brought up at the beginning of the talk, is that for some of the scenarios you can make things better. But they're not the dominant scenarios. They're the ones, the extra --

MEMBER BROWN: Well, I presumed these were the dominant scenarios.

MR. WACHOWIAK: No, those are frequency weighted so that it gives you a characterization of the dominant scenarios.

MEMBER BROWN: And those are the ones with the highest probability of occurrence?

MR. WACHOWIAK: Yes.

MEMBER BROWN: Typically.

MR. KRAFT: Well, the non-dominant scenarios are in there, but the frequency's so low it doesn't affect the bar graph.

MR. WACHOWIAK: Yes. The non-dominant one's in there, but they don't make the bar go up very much more.

MR. TRUE: Okay. I'm going back to Jeff. And he's going to walk through some --

MR. GABOR: Were we, I think, we were out here to discuss the EPRI strategy report. I think we covered some of this. So I will move quickly. We are going to do, like the NRC, we will do analysis on the Mark II, very similar to what you've heard on the Mark I.

Now, the Mark II designs can vary considerably from plant to plant. There are five sites that have Mark II plants. And I can tell you that each one of them has some unique containment features, things like the presence and the type of drain line beneath the reactor vessel, whether or not that region below the vessel is sunken or is it even with the drywell floor, whether or not there are downcomers in that sunken part of the pedestal.

And as the NRC pointed out this morning, whether or not there's water beneath the vessel in what you might call the lower pedestal. All of those four attributes can affect the accident progression. It may require that we do some, it will likely require we look at some multiple little technical evaluations.

A couple of NUREGs out there, Oak Ridge put together 5623. CR 5623 and 5528 are great references. There was a lot of good work, especially 5623 where they looked, after the kind of the IPE days where we're kind of winding down, they studied, and everybody kind of took, everybody was kind of picking on the Mark Is, late '80s. And Oak Ridge started to look more closely at the Mark II containments.

MEMBER CORRADINI: This was when?

MR. GABOR: '90.

MEMBER CORRADINI: This was Hodge and Green?

MR. GABOR: Some Green, Casey Wagner was on it.

MEMBER CORRADINI: At 5650 --

MR. GABOR: Yes. That group. The primary focus for us is to better understand whether or not there's a mechanism to create a suppression pool bypass. Because when we open all these accidents we've been talking about, we're primarily benefitting by opening the wetwell vent, we're getting the benefit of suppression pool scrubbing.

If there is a mechanism in Mark II to create a bypass, just having the bypass by itself doesn't necessarily mean bad things. But we want to make sure that we understand what impact it has on the results.

The NUREG, I think it was the 5623, whatever that one was, was that one, 5623 had this picture in it with these names. So I'm not doing anything out of school here.

Bottom left was a picture of Shoreham that I decided to take off for obvious reasons. But you can see the top two, Limerick and Susquehanna, you can see how their pedestal floor and the drywell floors are kind of even with each other. So that provides a potential mechanism for debris to spread out on the floor.

Where you go to the next two, LaSalle which is the reference plant that the NRC talked about, and WNP-2, and also Columbia and also Nine Mile Point, their cavities are sunken down. That tends to kind of keep, especially under low pressure conditions, keeps the debris focused in that under-pedestal or in that under-vessel region.

And what I didn't show here are any drain lines. But you can see in the bottom right, Nine Mile has the additional features which actually look a lot like the Shoreham design where they have these downcomer pipes directly beneath the R.V. So there is some variability here that we need to be, we need to make sure we address.

As far as drain line, I think we probably showed you this exact same picture back in the EPRI filtering strategy, but in concept it looks something like this, where there's a sump, potentially a sump, or just a plate or just a sloped floor and a four inch drain line that penetrates this floor, this diaphragm which is probably three feet thick.

So the potential for debris to get in there can be likely, depending on the accident progression and the melt core characteristics. And a lot of this was looked at in detail by Green, and Casey Wagner and others, Hodge and others at Oak Ridge in the 90s.

But that has a potential of failing. If it does, it could create a way for gases up here in the drywell to migrate down into the wetwell and then potentially out through an open vent line.

You notice that the one I picked here to show is actually LaSalle. And interestingly enough, of all the five plants, Mark II sites, it's the only one that has concrete underneath here. So it's fairly, it's quite unique.

On the other hand, if we're looking at scenarios where we're going to pour water into the RPV as a mitigation strategy, water's going to follow the debris wherever it goes and likely provide the cooling that we're looking for.

MEMBER CORRADINI: And isn't -- now I don't remember. Which one of these five actually has a separate pool of water right below the --

MR. GABOR: They all do, except for LaSalle. It's not really a separate pool. I think --

MEMBER CORRADINI: Oh, so they are connected. So if I heat up the outside, I heat up the inside.

MR. GABOR: Yes. What we do in our model --

MEMBER CORRADINI: I'm actually going to ask about your little dark blue, light blues.

MR. GABOR: Yes, yes. So dark blue -- and what it is, it's the pedestal itself is just extended all the way down into the wetwell. And typically the ones I've seen have got, in the underwater area, there'll be four at 90 degree, around 90 degree segments. They'll have four big openings. And then up in the gas space will be at least another set of those similar openings.

MEMBER CORRADINI: So there's communication. So if I heat the outside annulus, I heat the water below?

MR. GABOR: Correct.

MEMBER CORRADINI: Okay.

MR. GABOR: And our models, I'm sure, are the same as MELCOR. If I drop the debris down into that central pool, it's going to heat that up. And it's going to start exchanging through natural circulation. It's going to start communicating out here with the bigger pool.

But there'll be a lag. And the model has to be able to cope with that and the resulting pressurization that comes from that. I just tried to show here, I don't think we have to go through any gory details.

MEMBER CORRADINI: Are those pools?

MR. GABOR: The suppression pool, the Mark II, Phil? The sup pool or the Mark II?

MR. AMWAY: In terms of the volume?

(Simultaneous speaking.)

MR. AMWAY: The normal water depth is about 25 feet.

MEMBER CORRADINI: Yes. You're going to have different cooling there. You're going to have different cooling.

MR. AMWAY: Correct.

MEMBER CORRADINI: And you're calculating the different cooling?

MR. GABOR: The models, Rick can help me. The models in that do recognize deep water pools and the ability to cool debris as it falls through that deep pool.

MEMBER CORRADINI: That's okay. I won't say any more.

MR. GABOR: These three pictures we tried to --

MEMBER CORRADINI: Since I'm asking these questions as we go along, the one thing that I'm guessing is the difference between MAPP and MELCOR is the metal fraction that's going into any sort of deep water pool. In other words, the amount of oxide versus metal matters.

In a soon to be sort of an application to certified design in front of the NRC it matters, from a Gen III+ plant. So I think it matters. So those sorts of things at least ought to be considered. Okay, fine.

MR. GABOR: Yes. So they're all unique but since we actually, in the utility we had a workshop a month or so ago where we brought in each of the owners of each of the Mark II plants. We got all the drawings on the table. We identified a lot of the unique features of the plants. It was a really worthwhile exercise.

A lot of the data that came out of that exercise is the data set that's been communicated to the NRC. So again, the idea is we want to make sure that any conclusions we draw on the Mark II, just like we would on the Mark I, is a robust enough answer that, if there are plant to plant variabilities we've addressed those.

Our analysis is, for the Mark II, is going to follow closely, very closely to the Mark I design. We've got a Mark II APET. It's going look very similar to the containment event tree that we built for the Mark I.

The difference being this possibility of pool bypass. That didn't exist in the Mark I. It does exist in the Mark II. Other than that, the trees are going to look very similar. We're going to have venting. The venting could work, it can fail. It could wetwell, could go drywell. So that'd be similar.

And all we tried to show down at the bottom of the figure here is that there is a potential that we may have to do more than one Mark II design, either through sensitivities or actually representing it. And there's probably a half a dozen parameters that we can identify that can model the variation between these designs.

Again, we want to make sure our conclusions are robust to cope with that. And with that, I am done talking about Mark IIs.

MR. WACHOWIAK: Okay. So just to sum up what we've said over the last couple of hours, doing this evaluation here in this part of the rulemaking, we identified that the water addition is necessary, and it's important and suggested that it should be pulled up sooner in the time line, that people should consider doing that now. The plant should consider doing that now.

What's that? I'm sorry, And the severe accident management actions that we need to take in all these events, they are controlled by people. And we need to have wetwell venting and water addition. And as we said earlier, we couldn't identify a passive backfit that didn't adversely affect us on the core damage side.

We think that the water addition and venting gets us most of the benefit. We saw that in most of the bar charts there. And we didn't explicitly say it, but you probably kind of picked up on it. It didn't really matter which figure of merit we were looking at. We were getting the same answer however we were looking at the end result.

We're still looking at this bypass issue. We're going to have to look at, you know, your question here about what happens when core debris, although delayed, maybe in Nine Mile case not delayed, but the way it goes into the pool and what effects it might have from that.

MEMBER CORRADINI: Again, I'm sorry, you're --

MR. WACHOWIAK: The metal content.

MEMBER CORRADINI: The metal content. Oh, the way you said it I thought it was something different, I'm sorry.

MR. WACHOWIAK: Well, it's not exactly like the core debris comes from the vessel in the same composition that it came out of the vessel immediately into the lower plenum in many of the Mark II designs. Other stuff's going to happen first --

MEMBER CORRADINI: No, I understand.

MR. WACHOWIAK: -- before it gets there.

MEMBER CORRADINI: But where I'm going with this, yes, I'll just say where I'm going with it. What I'm going with is you might have enhanced cooling and lack of concern if you actually had a large metal content and saturated water. What you're looking for is to produce gases that essentially give you agitation but not detonation, enhanced --

MR. TRUE: Not super-enhanced.

MEMBER CORRADINI: Not a super-enhanced. I understand. And the only reason I'm saying that is that there was a large study done by the Swedish plants 20 years ago that we participated in that went through a whole range of calculations along the same set. That's all, I guess.

MR. WACHOWIAK: Right. So that all has to be looked at yet.

CHAIRMAN SCHULTZ: Good, I appreciate industry's presentations to this point, I think more coming. But this is a good time to ask the committee if they have any other questions before this panel leaves us. Any additional questions at this point in time?

MEMBER CORRADINI: Are we going to see all of this again before December and the draft regulatory basis? Or is this our one and only --

CHAIRMAN SCHULTZ: We don't have anything on calendar at this point.

MEMBER CORRADINI: What does the Chairman feel?

CHAIRMAN SCHULTZ: I feel it would be good for us to see something again at some point. And we can talk about when.

MEMBER CORRADINI: My only comment is I think some of the questions they asked us, these folks and the staff kind of want to do a cross-comparison --

CHAIRMAN SCHULTZ: I think that's right.

MEMBER CORRADINI: -- and after the cross-comparison is done, it would be good to have them tell us what they found. And that would be very informative --

CHAIRMAN SCHULTZ: I agree.

MEMBER REMPE: With some documentation, because the results seem, especially in the staff case, right off the press. And so it would be good to have that too.

CHAIRMAN SCHULTZ: We'll confer with the staff and get some idea of when they feel it would be the right time to get together again. But I think it would be very valuable, so we don't get caught short during public comment period or around that time when we feel we need to make some --

MR. KRAFT: Well, Mr. Chairman, yesterday when we were told the public comment period on the draft was 45 days, and it's a significant volume of material, we did ask whether there could be earlier drafts, but kind of an ongoing review. And I think Aaron said he would be looking at that and discussion drafts.

That would help everyone involved in looking at it, because I --

CHAIRMAN SCHULTZ: It would.

MR. KRAFT: -- I think if you just got hit with a 45 day review requirement, there are parties that would ask for an extension right off the bat. Because this is a short period of time, since it's a large volume of material.

CHAIRMAN SCHULTZ: Yes. We didn't bring that up, because it was administrative. But I certainly appreciate the comment. That seems very short.

Other questions or comments at this point in time? With that, because we do have the closed session coming up, as I mentioned earlier, I would like to provide this opportunity for public comment on the record.

John, if we get the phone line open, while that's happening I'll ask if anyone in the audience here, if anyone would like to make a comment for the record, now would be the time to do so.

Not seeing anyone come forward then, I'll wait until we hear that the phone line is open. And before anyone starts talking on the phone line, keep faith for a moment, I do hear it now open. I believe it is open.

And if you're out there listening, if you would please just state your name so that we know or let us know that you're hearing us at this point so we can know that you're on the line. Is anyone out there?

NIKKI: Hi, Nikki from Palm Springs.

CHAIRMAN SCHULTZ: Hi, Nikki. Would you like to make a comment?

NIKKI: I actually have just a list of questions that I was going to type up and send to somebody. So if I could get a specific place where to send them, because I'm a little bit of newbie. So I think I have a little bit of background to catch up on.

CHAIRMAN SCHULTZ: Okay.

NIKKI: But my one main question is what happens to this water when it becomes radioactive?

CHAIRMAN SCHULTZ: Okay. The --

NIKKI: And I know that it's beyond the purview of what you guys were discussing a little bit, but when you guys were talking about putting water on it to cool it and the levels of that, I had to question is there another fluid that would work better?

CHAIRMAN SCHULTZ: Yes, I understand the questions you would like to ask, and what we would like to do, you'll see in the agenda and the notice of the meeting that in the notice of the meeting there is a contact information for the NRC that you can, so we can give you an opportunity to connect to.

NIKKI: Okay. Perhaps the only question that I have that somebody in the room can answer was the statement that was made that it says when the temperatures go up a certain amount and they said that wasn't a viable option --

CHAIRMAN SCHULTZ: You're, excuse me, ma'am. You're breaking up a little bit. So if you're on a speaker phone, can you use a regular phone or something. Because you just started cutting out. And so that we make sure you're on the record, it would help if you have a -- I don't know what sort of communication device you're using, but try something else.

NIKKI: Oh, I'm on a cell phone.

CHAIRMAN SCHULTZ: Okay, that's a little bit better, whatever you just did is a little bit better.

NIKKI: I did nothing different.

CHAIRMAN SCHULTZ: Okay. It settled out. It's just we like to make sure that we get all your comments on the record. And occasionally you were cutting out when you, and then we can follow-up. We can follow-up with you on an answer to a question that you may have.

But the format that we have is not to have a Q&A session, a question and answer session with the public, but just have the public raise concerns on the record. And --

NIKKI: Okay. And then I guess I'll just say my biggest concern is what happens when water becomes radioactive.

CHAIRMAN SCHULTZ: Okay.

NIKKI: And overall contamination.

CHAIRMAN SCHULTZ: Let me give you a contact. It's on the record, the written record for the meeting. And that is to John Lai, L-A-I. And the number is (301)415-5197.

NIKKI: All right.

CHAIRMAN SCHULTZ: And you may contact him next week.

MEMBER STETKAR: Contact John, and if you want to submit things in writing which you mentioned, John will give you an email address and ways of getting the information to us. And we'll make sure that they're included in the record of this meeting if you submit things in writing also.

NIKKI: Excellent. Thank you.

CHAIRMAN SCHULTZ: Yes, thank you for --

NIKKI: And thanks for your work. It was very interesting, over my head, but interesting.

CHAIRMAN SCHULTZ: Thanks for your participation. Are there other members of the public who would like to make a statement or comment? Please identify yourself.

(No audible response.)

CHAIRMAN SCHULTZ: Hearing none at this time then we'll go ahead and close the phone line. And at this time, I'm going to close the open session.

(Off the record comments.)

And at this time, we are going to ask the members of industry and the NRC to make sure that they're covered with regard to confidential information. I'm looking around the room, but it's not our responsibility to do that.

(Whereupon, the above-entitled matter went off the record at 4:12 p.m. and resumed at 6:36 p.m.)

CHAIRMAN SCHULTZ: Dick? Your comments on the materials that we discussed today?

MEMBER SKILLMAN: Just thank you to the staff and to the industry for the effort that they have obviously poured into these presentations for today. Thank you.

CHAIRMAN SCHULTZ: John?

MEMBER STETKAR: Yes, I'll echo Dick's, and I think that, and I really appreciate the staff and the industry assembling all this and coming in, you know, when you did, in a really timely manner. We had discussions about this, I don't know, in June, was it, Steve?

CHAIRMAN SCHULTZ: Yes, it was.

MEMBER STETKAR: And getting all of this material in so that we could have this type of discussion now rather than November or December is really, really useful I think, to us and I hope also to you. Thanks for pulling it off.

MR. PETERS: I think it's been very useful to us and given us a lot of key takeaways that we can work on, so we really appreciate that.

CHAIRMAN SCHULTZ: Dennis?

MEMBER BLEY: No, I would echo the other comments, and good luck.

CHAIRMAN SCHULTZ: Ron?

MEMBER BALLINGER: Same thing, but I think this getting convergence or confluence or -- between the -- between the earlier stuff that was this morning or this afternoon, I keep -- I've lost track of time, and what you're doing I think is very important. Otherwise, it's going to have to be done at some point.

MR. PETERS: You guys have seen plenty of Susan Cooper presentations on PRA and HRA, and they show this continuous looping process, so yes, we have to take this HRA information and feed it back into those PRA models in some fashion. You're absolutely right.

MEMBER BALLINGER: And I think that was pretty much brought home.

CHAIRMAN SCHULTZ: Good. Joy?

MEMBER REMPE: Well, I also appreciate the presentations from the staff and industry, and I think the one additional point I might remind folks is of the, we discussed about having some sort of written material in the meeting in December and --

MEMBER STETKAR: We agreed with the staff that they didn't need to provide written documentation because of the timing on this.

MEMBER REMPE: I understand that now, but for December, if we can get anything earlier than two weeks before the meeting, it would be great because I heard it was --

(Simultaneous speaking.)

MEMBER STETKAR: To start the heroic stuff to get this stuff assembled and to us.

MEMBER REMPE: And I understand that.

CHAIRMAN SCHULTZ: My comment is to first echo the, my thanks to the staff, and as John has indicated, it is extremely important that we had this meeting, and so we really appreciate the efforts of industry and the staff to not only bring good material to us but to report on very present day information.

A lot has come together just recently, as yesterday, and we heard about it today, which is almost remarkable, so -- and I was glad to see the level of analysis that has been done and the presentations on -- both by the staff and by the industry demonstrated how we're really looking hard at developing ways to present the information in a different fashion that does express better what we're learning in terms of conclusions. Because that's going to be extremely important for the decision-making that's associated with this overall program and process. So that was very encouraging.

Now administratively we're going to have to work on how the -- I'm glad you picked up good information from ACRS meeting today and have taken notes, but we also have to work, John, with the staff to see what our next steps ought to be because we do want to contribute wholeheart -- in a wholehearted fashion to the draft that's coming out, as well as provide comments on that draft.

So logistically, as Joy said, we have to work on how to do that, how to accomplish that, without slowing down a process that's marching forward. So we will take that on, most likely starting in the September time-frame.

Any other comments?

All right, with that I'll close the record for the meeting. Thank you very much.

(Whereupon, the meeting in the above-entitled matter went off the record at 6:41 p.m.)

United States Nuclear Regulatory Commission

Protecting People and the Environment

ACRS Subcommittee Meeting: Filtering Strategies and Severe Accident Management for BWR with Mark I and Mark II Containments Rulemaking

August 22, 2014

Aaron Szabo, NRR/DPR

Agenda

- History
- Purpose
- Process and Schedule
  - Regulatory basis development
- Alternatives Evaluated
- Performance Goal
- Status

History

- Staff provided Commission SECY-12-0157 that recommended an order to install filters on all BWR Mark I and Mark II Containments
- SRM to SECY-12-0157 required installation of severe accident capable vents and directed the staff to perform rulemaking
  - Before core damage venting has been justified as Adequate Protection (EA-12-050)
  - Post core damage venting has been justified as a Cost-Justified Substantial Safety Enhancement (EA-13-109)

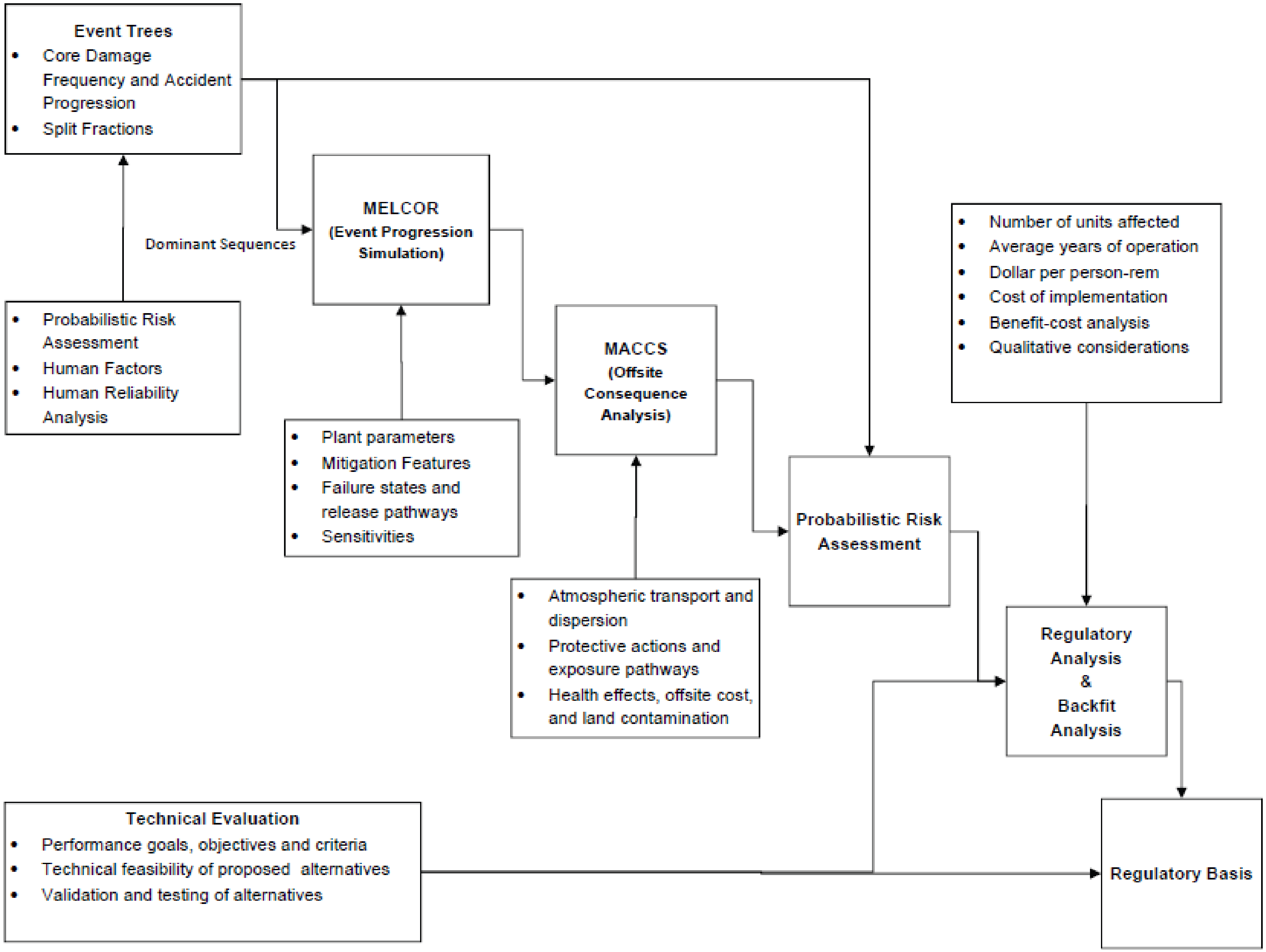
Purpose

- Define performance-based requirements to address the potential release of significant amounts of radioactive material from containment following the dominant severe accident sequences at boiling water reactors with Mark I and Mark II containments and establish acceptance criteria for confinement strategies

Process and Schedule

- Draft Regulatory Basis: ~Dec. 2014
  - 45-day public comment period to follow
- Final Regulatory Basis: Sept. 2015
- Proposed Rule: Sept. 2016
  - Draft regulatory guide to be included
- Final Rule: Dec. 2017
  - Final regulatory guide to be included
- Implementation: 2019 – 2022

Draft Regulatory Basis Development



Performance Goal

- Protect public health and safety by minimizing potential release of significant amounts of radioactive material following severe accident sequences through containment failure prevention measures and release reduction measures for BWR with Mark I and Mark II containments.

Alternatives Evaluated

1. No action/Status Quo
2. Overpressurization Measures
   - Codify EA-13-109
3. Containment Failure Prevention (CFP) Measures
   A. Water addition via RPV
   B. Water addition via Drywell
4. Release Reduction + CFP Measures
   A. Filtration Strategies
   B. Small Filter
   C. Large Filter

Rulemaking Name Change

- Due to the alternatives that are currently evaluated in the staff's analysis, the staff has renamed the rulemaking to:

Containment Protection and Release Reduction for BWR with Mark I and Mark II Containments (CPRR) Rulemaking

Status

- Developing draft regulatory basis with significant interaction with public
  - 12 public meetings involving the rulemaking
- Developing performance goals and criteria
- Completing and concurrently developing stages of rulemaking

Contact Information

- Aaron L. Szabo, Cost Analyst
  - Office of Nuclear Reactor Regulation, Division of Policy and Rulemaking, Rulemaking Branch
  - 301-415-1985
  - Aaron.Szabo@NRC.gov

Backup Slides

Public Meeting Summaries and Related Documents

- August 21, 2014 (in progress)
- June 18-19, 2014 (ML14176B132)
- June 4, 2014 meeting between ERIN and NRC/RES
- May 31, 2014 NEI response on detailed cost estimates
- NRC letter to NEI (ML14134A055)
- April 30, 2014 (ML14136A292)

Public Meeting Summaries and Related Documents (cont'd)

- April 18, 2014 letter to ERIN from NRC/RES on MACCS input code (ML14108A261)
- March 26-27, 2014 (ML14093A098)
- January 2014 phone call between NRC/NRR and NEI (ML14035A156)
- December 12, 2013 (ML13357A794)

Public Meeting Summaries and Related Documents (cont'd)

- November 12, 2013 NEI workshop presentation (ML13337A500)
- November 6, 2013 (ML13324A953)
- September 19, 2013 (ML13277A332)
- August 14, 2013 (ML13238A328)
- July 11, 2013 (ML13211A395)
- June 26, 2013 (ML13203A074)
- June 13, 2013 (ML13199A216)

Acronyms and Abbreviations

- AC – Alternating Current
- ACRS – Advisory Committee on Reactor Safeguards
- APET – Accident Progression Event Tree
- AV – Anticipatory Venting
- BWR – Boiling Water Reactor
- BWROG – Boiling Water Reactor Owners Group
- CCDP – Conditional Core Damage Probability
- CDET – Core Damage Event Tree
- CDF – Core Damage Frequency
- CFP – Containment Failure Prevention
- CST – Containment Storage Tank
- DC – Direct Current
- DF – Decontamination Factor
- DW – Drywell
- DWF – Drywell-First Venting Strategy
- EDO – Executive Director for Operations
- ELAP – Extended Loss of AC Power
- EPG – Emergency Procedure Guidelines

Acronyms and Abbreviations

- EPRI – Electric Power Research Institute
- EPS – Emergency Power System
- FLEX – Diverse and Flexible Coping Strategies
- HEP – Human Error Probability
- IC – Isolation Condenser
- LOOP – Loss of Offsite Power
- MACCS – MELCOR Accident Consequence Code System
- MSL – Main Steam Line
- NEI – Nuclear Energy Institute
- NRC – U.S. Nuclear Regulatory Commission
- NRR – Office of Nuclear Reactor Regulation
- PCPL – Primary Containment Pressure Limit
- PRA – Probabilistic Risk Assessment
- PSIG – Pound per Square Inch
- RC – Release Category
- RCIC – Reactor Core Isolation Cooling
- RES – Office of Nuclear Regulatory Research
- RPV – Reactor Pressure Vessel
- SAG – Severe Accident Guidelines

Acronyms and Abbreviations

- SAMG – Severe Accident Management Guidelines
- SBO – Station Blackout
- SP – Suppression Pool
- SRM – Staff Requirements Memorandum
- SRV – Safety Relief Valve
- TSC – Technical Support Center
- WW – Wetwell
- WWF – Wetwell-First Venting Strategy

Risk Evaluation

ACRS Meeting
August 22, 2014

Marty Stutzke, RES/DRA

Overview

- Purpose of the risk evaluation: Assess the change in risk due to various containment protection and release reduction (CPRR) alternatives.
- Topics to be discussed:
  - Extended loss of AC power (ELAP) event frequencies:
    - Considerations
    - Preliminary results
  - Core-damage event tree (CDET)
    - Development
    - Preliminary results
  - Accident progression event tree (APET) development
    - Development
    - Preliminary results
  - Plans for sensitivity analyses
  - Path forward

ELAP Frequencies

- ELAP frequency = frequency of SBOs with duration > SBO coping time required by 10 CFR 50.63 (Loss of all alternating current power)
- Two contributors included:
  - Internal events as defined by NUREG/CR-6890:
    - Plant-centered LOOPs
    - Switchyard-centered LOOPs
    - Grid-related LOOPs
    - Weather-related LOOPs
  - Seismic events
- Contribution from other types of external events (e.g., high winds) has not been estimated:
  - At the edge of current PRA state-of-practice
  - May be significant
  - Source of completeness uncertainty
- Note: CPRR strategies may be beneficial for accidents initiated by events other than ELAP
  - Source of completeness uncertainty

ELAP Frequencies (Con't.)

- ELAP frequencies are site-specific:
  - SBO coping duration (NUREG/CR-5500, Vol.5)
  - Number of onsite emergency AC sources (NUREG/CR-5500, Vol. 5)
  - Seismic hazard (NTTF Rec. 2.1 information request, except Columbia and Vermont Yankee)
- ELAP frequency estimates consider:
  - Random equipment failure
  - Common-cause failures
  - Seismic failure of:
    - AC switchgear
    - Batteries
    - DC switchgear
    - Emergency diesel generators
    - Offsite power (ceramic insulators in the switchyard)

Estimated ELAP Frequencies

Site	Containment Type	Notes	EPS Class	SBO Coping Time	Internal Hazard ELAP	Seismic ELAP	Seismic ELAP DC ↑ RCIC-ST ↑	Seismic ELAP DC ↑ RCIC-ST ↓	Seismic ELAP DC ↓ RCIC-ST ↑	Seismic ELAP DC ↓ RCIC-ST ↓
							Seq. 1-224	Seq. 225-226	Seq. 227-338	Seq. 339-340
Browns Ferry	Mark I		4	4	7.3E-07	5.9E-07	2.0E-07	7.5E-08	1.8E-07	1.3E-07
Brunswick	Mark I		2	4	1.3E-05	3.6E-07	2.4E-07	2.5E-08	5.6E-08	3.7E-08
Columbia	Mark II		2	4	1.3E-05	9.0E-07	n/a	n/a	n/a	n/a
Cooper	Mark I		2	4	1.3E-05	1.7E-07	1.1E-07	1.2E-08	2.8E-08	1.7E-08
Dresden	Mark I	IC	4	4	7.3E-07	5.2E-07	n/a	n/a	n/a	n/a
Duane Arnold	Mark I		2	4	1.3E-05	1.1E-07	5.9E-08	1.1E-08	2.3E-08	1.7E-08
Fermi	Mark I		4	4	7.3E-07	2.7E-07	9.2E-08	3.4E-08	8.1E-08	5.9E-08
FitzPatrick	Mark I		4	4	7.3E-07	9.7E-08	3.3E-08	1.2E-08	2.9E-08	2.1E-08
Hatch	Mark I		3	4	6.6E-06	6.4E-08	5.0E-08	3.0E-09	7.1E-09	3.7E-09
Hope Creek	Mark I		3	4	6.6E-06	1.7E-07	1.0E-07	1.4E-08	3.5E-08	1.9E-08
La Salle	Mark II		3	4	6.6E-06	8.5E-07	n/a	n/a	n/a	n/a
Limerick	Mark II		4	4	7.3E-07	2.9E-07	n/a	n/a	n/a	n/a
Monticello	Mark I		2	4	1.3E-05	3.0E-07	1.7E-07	2.8E-08	6.4E-08	4.5E-08
Nine Mile Point	Mark I/II	IC	2	4	1.3E-05	1.6E-07	n/a	n/a	n/a	n/a
Oyster Creek	Mark I	IC	2	4	1.3E-05	2.5E-07	n/a	n/a	n/a	n/a
Peach Bottom	Mark I		3	8	5.0E-06	2.5E-06	9.1E-07	3.1E-07	6.7E-07	6.4E-07
Pilgrim	Mark I		2	8	9.9E-06	4.0E-06	1.9E-06	4.3E-07	9.4E-07	7.4E-07
Quad Cities	Mark I		4	4	7.3E-07	2.4E-07	7.9E-08	3.1E-08	7.2E-08	5.3E-08
Susquehanna	Mark II		3	4	6.6E-06	1.8E-07	n/a	n/a	n/a	n/a
Vermont Yankee	Mark I	shutdown	2	8	9.9E-06	5.5E-07	3.6E-07	3.7E-08	1.3E-07	2.8E-08

Core-Damage Event Tree (CDET) Development

- Generic model of FLEX Phase 1 and Phase 2 strategies for BWR Mark I plants with RCIC systems:
  - Portable FLEX pump for:
    - Suppression pool makeup
    - RPV injection
  - Emergency generator to recharge batteries
- Anticipatory containment venting strategies:
  - Wetwell-first (WWF)
  - Drywell-first (DWF)
- Reclosure of containment vents upon core damage
- Consideration of local manual operator actions upon loss of DC power:
  - RCIC blackstart and black run
  - SRV operation
  - Containment vent operation
- Preliminary point estimates for human error probabilities (HEPs)
  - In-control room: 0.1
  - Outside of the control room: 0.3
- Two CDETs (WWF and DWF), each containing:
  - 320 total sequences
  - 280 core-damage sequences
  - 139 realized plant damage states (PDSs)

Plant Damage States

T-PP-VV-DD-F

- RCIC failure time
  - E: early (0-4h)
  - M: mid-term (4-16h)
  - L: long-term (at 16h)
- RVP pressure
  - HP: high pressure (SRV cycling)
  - MP: medium pressure (200-400 psig)
  - LP: low pressure (below portable FLEX pump shutoff head)
- Containment vent status:
  - DW: drywell vent is open at time of core damage
  - IS: both vents are closed at the time of core damage
  - WW: wetwell vent is open at the time of core damage
- DC power status
  - LT: DC power fails long-term (unrecovered battery depletion)
  - OK: DC power is available throughout the accident
  - ST: DC power fails short-term (before battery depletion)
  - XX: indeterminate (DC power status not important to subsequent logic)
- FLEX pump staus
  - OK: portable FLEX pump is working
  - F: FLEX pump hardware is failed
  - H: Operator fails to align FLEX prior to core damage
  - XX: indeterminate (FLEX pump status not asked in the core-damage sequence)

Conditional Core-Damage Probabilities

Plant	EPS Class	SBO Coping Time Time (h)	Internal Hazards			Seismic			Total		
			ELAP Frequency	CDF	CCDP	ELAP Frequency	CDF	CCDP	ELAP Frequency	CDF	CCDP
Browns Ferry	4	4	7.3E-07	2.6E-07	0.36	5.9E-07	3.6E-07	0.61	1.3E-06	6.2E-07	0.47
Brunswick	2	4	1.3E-05	4.7E-06	0.36	3.6E-07	1.7E-07	0.48	1.3E-05	4.8E-06	0.36
Cooper	2	4	1.3E-05	4.7E-06	0.36	1.7E-07	8.0E-08	0.48	1.3E-05	4.7E-06	0.36
Duane Arnold	2	4	1.3E-05	4.7E-06	0.36	1.1E-07	5.9E-08	0.54	1.3E-05	4.7E-06	0.36
Fermi	4	4	7.3E-07	2.6E-07	0.36	2.7E-07	1.6E-07	0.61	1.0E-06	4.2E-07	0.43
FitzPatrick	4	4	7.3E-07	2.6E-07	0.36	9.7E-08	5.9E-08	0.61	8.3E-07	3.2E-07	0.39
Hatch	3	4	6.6E-06	2.4E-06	0.36	6.4E-08	2.8E-08	0.43	6.7E-06	2.4E-06	0.36
Hope Creek	3	4	6.6E-06	2.4E-06	0.36	1.7E-07	8.5E-08	0.50	6.8E-06	2.5E-06	0.36
Monticello	2	4	1.3E-05	4.7E-06	0.36	3.0E-07	1.6E-07	0.53	1.3E-05	4.8E-06	0.36
Peach Bottom	3	8	5.0E-06	1.8E-06	0.36	2.5E-06	1.6E-06	0.62	7.5E-06	3.4E-06	0.45
Pilgrim	2	8	9.9E-06	3.5E-06	0.36	4.0E-06	2.3E-06	0.56	1.4E-05	5.8E-06	0.42
Quad Cities	4	4	7.3E-07	2.6E-07	0.36	2.4E-07	1.4E-07	0.61	9.7E-07	4.1E-07	0.42

Significant Plant Damage States (Wetwell-First Venting Strategy)

Index	PDS	Frequency	Percent	Cumulative	Index	PDS	Frequency	Percent	Cumulative
1	L-MP-IS-OK-F	3.5E-07	12.1%	12.1%	24	M-LP-WW-OK-H	3.1E-08	1.1%	84.3%
2	M-LP-IS-OK-H	3.1E-07	10.5%	22.7%	25	L-MP-WW-LT-F	2.9E-08	1.0%	85.3%
3	L-MP-IS-OK-H	2.4E-07	8.2%	30.9%	26	M-MP-WW-LT-OK	2.5E-08	0.8%	86.2%
4	M-MP-IS-LT-XX	2.0E-07	6.7%	37.6%	27	L-MP-WW-OK-H	2.4E-08	0.8%	87.0%
5	M-LP-IS-LT-H	1.8E-07	6.0%	43.6%	28	L-HP-IS-OK-H	2.3E-08	0.8%	87.8%
6	E-LP-IS-XX-XX	1.3E-07	4.5%	48.1%	29	M-LP-WW-LT-F	2.0E-08	0.7%	88.5%
7	M-MP-IS-LT-H	1.2E-07	4.3%	52.4%	30	L-MP-WW-LT-H	1.9E-08	0.7%	89.1%
8	M-LP-IS-OK-F	1.0E-07	3.6%	56.0%	31	M-HP-IS-LT-XX	1.8E-08	0.6%	89.7%
9	E-LP-IS-ST-XX	1.0E-07	3.6%	59.6%	32	M-LP-DW-LT-H	1.7E-08	0.6%	90.3%
10	L-MP-IS-LT-F	8.7E-08	3.0%	62.5%	33	M-LP-IS-ST-H	1.5E-08	0.5%	90.9%
11	M-MP-IS-LT-OK	7.5E-08	2.6%	65.1%	34	E-HP-IS-XX-XX	1.4E-08	0.5%	91.4%
12	M-LP-IS-LT-F	6.0E-08	2.1%	67.2%	35	M-MP-WW-LT-F	1.4E-08	0.5%	91.8%
13	L-MP-IS-LT-H	5.9E-08	2.0%	69.2%	36	M-MP-DW-LT-H	1.2E-08	0.4%	92.3%
14	M-LP-WW-LT-H	5.8E-08	2.0%	71.2%	37	L-MP-WW-LT-OK	1.2E-08	0.4%	92.7%
15	L-MP-IS-OK-OK	4.7E-08	1.6%	72.8%	38	M-HP-IS-LT-H	1.1E-08	0.4%	93.1%
16	E-HP-IS-ST-XX	4.5E-08	1.5%	74.3%	39	L-HP-IS-LT-F	1.1E-08	0.4%	93.4%
17	M-MP-IS-LT-F	4.3E-08	1.5%	75.8%	40	M-LP-WW-OK-F	1.1E-08	0.4%	93.8%
18	M-MP-WW-LT-H	4.1E-08	1.4%	77.2%	41	L-MP-DW-LT-F	8.6E-09	0.3%	94.1%
19	M-LP-IS-LT-XX	3.7E-08	1.3%	78.5%	42	M-MP-IS-ST-XX	7.8E-09	0.3%	94.3%
20	L-MP-WW-OK-F	3.6E-08	1.2%	79.7%	43	M-MP-DW-LT-OK	7.4E-09	0.3%	94.6%
21	L-MP-IS-LT-OK	3.5E-08	1.2%	80.9%	44	L-HP-IS-LT-H	7.3E-09	0.2%	94.8%
22	M-MP-IS-OK-XX	3.4E-08	1.2%	82.1%	45	M-HP-IS-LT-OK	6.8E-09	0.2%	95.1%
23	L-HP-IS-OK-F	3.4E-08	1.2%	83.3%					

Total CDF = 2.9E-6/y

Accident Progression Event Tree (APET) Development

- Four APETs, corresponding to:
  - Destination of post-accident injection (RPV or DW)
  - Containment venting strategy (WWF or DWF)
- Consideration of local manual operator actions upon loss of DC power:
  - SRV operation
  - Containment vent operation
- Preliminary point estimates for human error probabilities (HEPs)
  - In-control room: 0.1
  - Outside of the control room: 0.3
- Branch probabilities depend on the specific PDS that is input
- Summary statistics
  - 72 sequences
  - Number of realized release categories (RCs) depends on the regulatory analysis alternative being modeled

Release Categories

RRRRR-VV-DDD

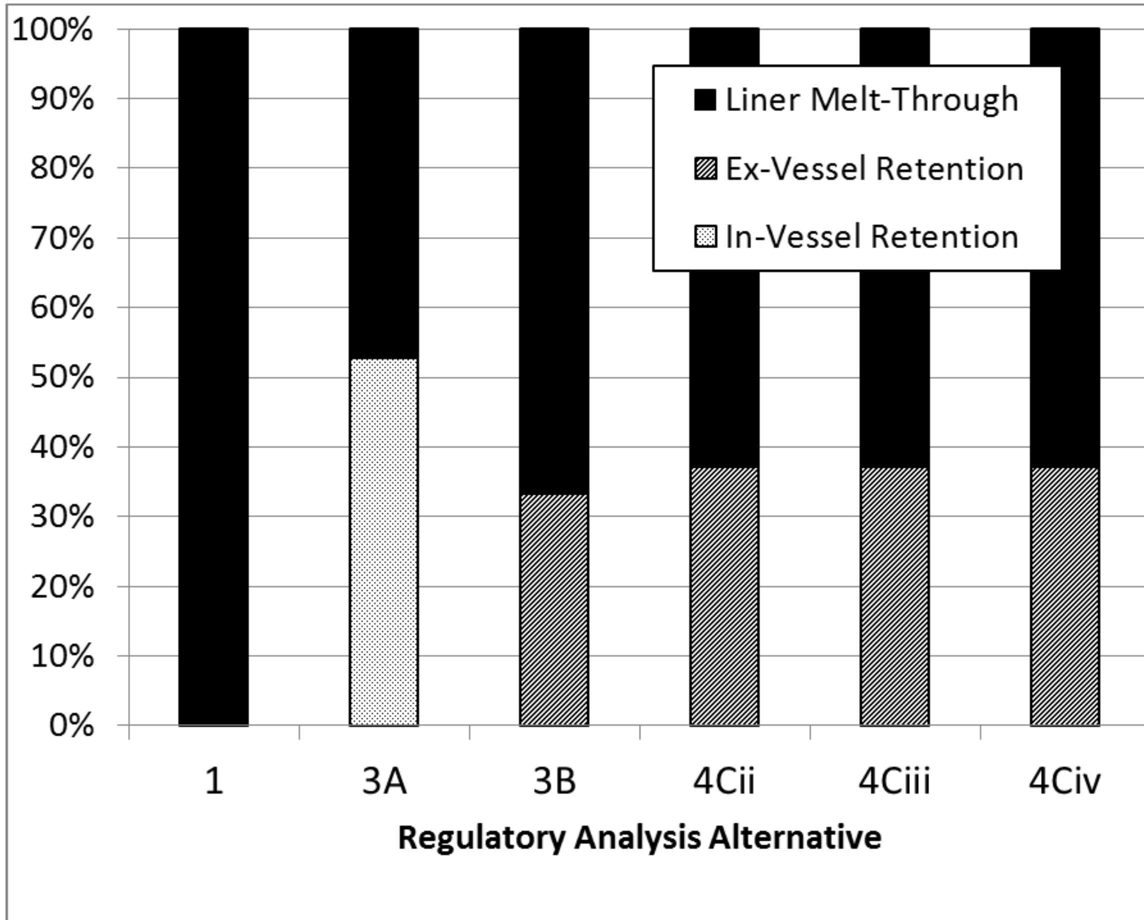
- RPV depressurization
  - SRV: RPV is depressurized using the SRVs
  - HP: RPV is at high pressure (high-pressure melt scenario)
  - MSLCR: RPV depressurized due to main steamline creep rupture
- Containment vent status
  - WW: wetwell vent is open
  - DW: drywell vent is open
  - OP: containment overpressurization failure
- Core debris location
  - IVR: in-vessel retention
  - EVR: ex-vessel retention
  - LMT: liner melt-through

Preliminary Risk Evaluation of Regulatory Analysis Alternatives

- Preliminary estimates of release sequence frequencies have been made for all regulatory analysis alternatives.
  - Alternative 3A is a surrogate for Alternatives 4Ai(1), 4Aii(1) and 4Aiii(1) (same logic structure and preliminary human error probabilities), and has the same frequencies as Alternatives 4Bi(1) and 4Ci(1)
  - Alternative 3B is a surrogate for Alternatives 4Ai(2), 4Aii(2) and 4Aiii(2) (same logic structure and preliminary human error probabilities), and has the same frequencies as Alternatives 4-Bi(2) and 4Ci(2)

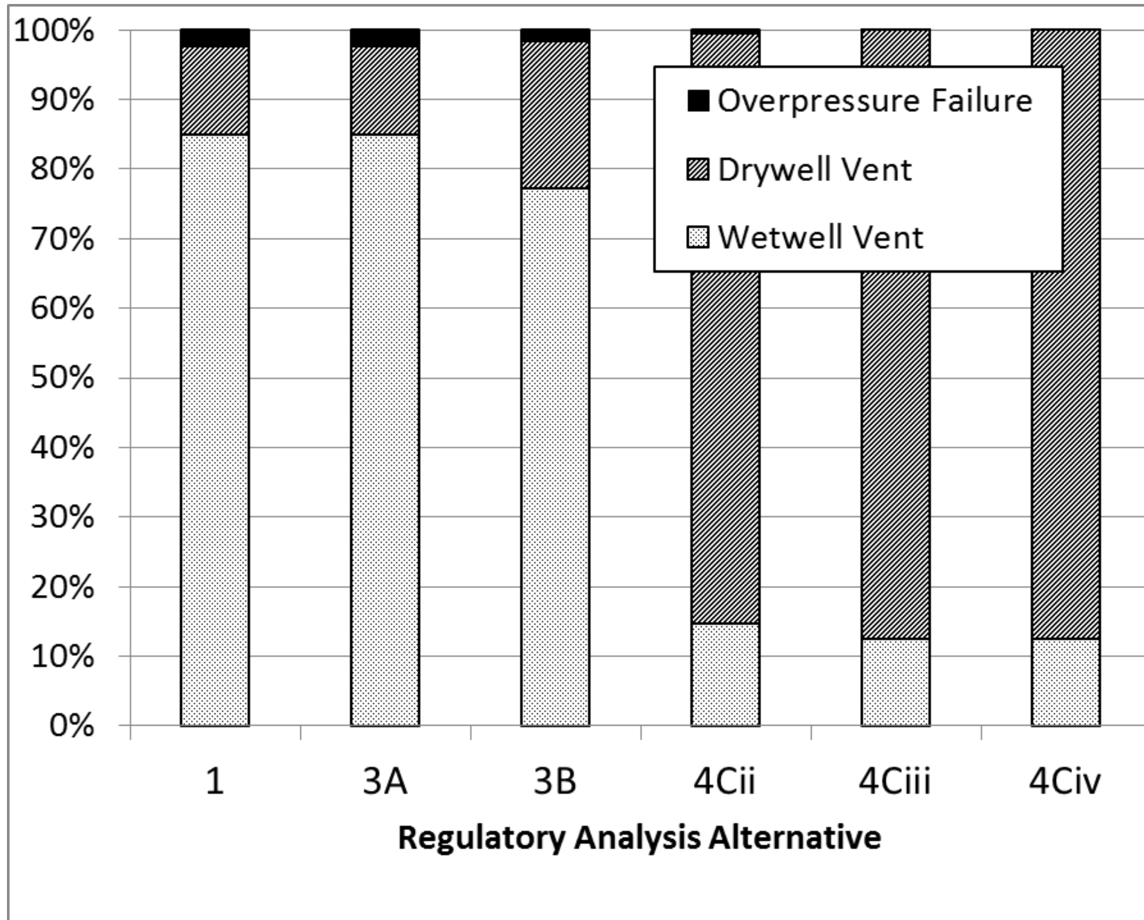
Breakdown by Core Debris Location

	Post-CD Injection	Containment Venting (pre-CD, post-CD)
1	none	none
3A	RPV	WWF (manual, manual)
3B	DW	WWF (manual, manual)
4Cii	DW	DWF (manual, manual)
4Ciii	DW	DWF(manual, passive)
4Civ	DW	DWF (passive, passive)



Breakdown by Containment Venting Status

	Post-CD Injection	Containment Venting (pre-CD, post-CD)
1	none	none
3A	RPV	WWF (manual, manual)
3B	DW	WWF (manual, manual)
4Cii	DW	DWF (manual, manual)
4Ciii	DW	DWF(manual, passive)
4Civ	DW	DWF (passive, passive)



Sensitivity Analyses

- Will conduct sensitivity analyses on all human error probabilities contained in CDETs and APETs:
  - Individual human failure events
  - All human failure events *en masse*
- Example:

	Core-Damage Frequency (/ry)		CCDP	
Site	**base line**	**all HEPs = 0**	**base line**	**all HEPs = 0**
Browns Ferry	6.2E-07	3.8E-07	47.1%	28.5%
Brunswick	4.8E-06	2.1E-06	36.2%	15.8%
Cooper	4.7E-06	2.1E-06	36.0%	15.6%
Duane Arnold	4.7E-06	2.0E-06	36.0%	15.6%
Fermi	4.2E-07	2.3E-07	42.5%	23.2%
FitzPatrick	3.2E-07	1.6E-07	38.8%	18.8%
Hatch	2.4E-06	1.0E-06	35.9%	15.5%
Hope Creek	2.5E-06	1.1E-06	36.2%	15.8%
Monticello	4.8E-06	2.1E-06	36.2%	15.9%
Peach Bottom	3.4E-06	2.0E-06	44.6%	25.9%
Pilgrim	5.8E-06	3.1E-06	41.8%	22.4%
Quad Cities	4.1E-07	2.2E-07	42.0%	22.6%
	2.9E-06	**1.4E-06**		

Path Forward

- Complete human reliability analysis (HRA)
- Estimate release frequencies for alternatives 4Ai(1), 4Aii(1), 4Aiii(1), 4Ai(2), 4Aii(2) and 4Aiii(2) after HRA is completed
- Estimate risks for all alternatives after MACCS calculations are completed
- Complete sensitivity analyses

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Containment Protection and Release Reduction Rulemaking: MELCOR Analysis

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MELCOR Analysis Basis

- MELCOR analysis run matrix covers alternatives/options considered for regulatory analysis
- Consistent with the SECY-12-0157 approach and complies with SRM for SECY-12-0157
- Builds upon information exchange between the industry and the NRC at previous public meetings
- Assumptions consistent with those of the industry
- Builds upon staff PRA for selection of dominant sequences
- Some differences between staff's and industry's PRA/HRA

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MELCOR Analysis General Assumptions

- All MELCOR transients start with an ELAP; 72 hour duration
- Order EA-13-109 capability assumed in place
- EPG/SAG Rev 3 assumed in place
- FLEX assumed in place both pre- and post-core damage; functionality of FLEX may vary
- Mitigation measures considered
- Possible end states of accident progression: Liner Melt Through (Mark-I), Main Steam Line Creep Rupture, DW head flange leakage by over pressure/temperature – all consequential to environmental release

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MELCOR Analysis Specific Assumptions

- RCIC operation
  - Suction from SP (option for suction from CST/SP)
  - Initial flow rate 600 gpm
  - RPV level control via throttling of RCIC
- RPV pressure control
  - Pressure control in 800–1000 psig band at 10 min
  - Controlled depressurization after one hour
  - Subsequent pressure control in 200 – 400 psig band for continued RCIC operation

MELCOR Analysis Specific Assumptions

- **Containment venting**
  - **Anticipatory venting prior to core damage (15 psig)**
  - **Upon entry into SAG vent closed; reopens at PCPL (60 psig) – option to reopen at PSP considered**
  - **Transition from WW to DW venting at SP high water level (21’ above bottom of torus)**
  - **Vent cycling in (PCPL)/(PCPL-10/20) band**

MELCOR Analysis Specific Assumptions

- **RPV or Drywell injection**
  - **500 gpm injection into drywell from an external source; injection at vessel breach**
  - **Flow rate control to prevent wetwell flooding or switchover to DW venting**
  - **MELCOR considers initial buildup of water in the drywell from nominal leakage**

MELCOR Analysis
Mapping to Regulatory Analysis Options

- Option 1: EA-13-109, EPG/SAG Rev 3, anticipatory venting, RPV pressure control
- Option 2A: Option 1 plus injection to RPV
- Option 2B: Option 2A plus WW/DW vent cycling
- Option 2C: Option 2B plus water management
- Option 2D: Option 2A plus water management
- Option 3A: Option 1 plus injection to drywell
- Option 3B: Option 3A plus WW/DW vent cycling
- Option 3C: Option 3B plus water management
- Option 3D: Option 3A plus water management

MELCOR Analysis
Output Parameters

- **Thermal-hydraulics**
  - **Containment pressure – increases as a result of in-vessel and ex-vessel gas generation (e.g., H2/CO) and impacts timing of venting or potential containment failure. Potential for combustion in reactor building.**
  - **Drywell structure temperature – potential failure of various components (e.g., DW head flange seal failure)**
  - **Wetwell (suppression pool) water temperature – impacts effectiveness of pool scrubbing and failure of RCIC**
- **Source term**
  - **Provides input to consequence analysis using MACCS**
  - **Cesium release – important contributor to latent cancer fatalities risk and land contamination calculations**
  - **Iodine release - important contributor to prompt fatalities and operator dose**

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MELCOR Run Matrix for Mark I

		Pre Core Damage						Post Core Damage				
		RPV Pressure control	RCIC Operation				Anticipatory Venting	Flex Operation		SRV Operation	Venting	
		Availability (hr)	RCIC Availability (hr)	RCIC Suction	Failure Temp (F)	Open SRV after RCIC fails	Setpoint (psig)	Injection @ LH failure	WW Level Control Injection @ 21' (gpm)	Allow SRV stuck open failure?	Location	Setpoint
Option	Case											
1	1	72	16	SP	230	N	15	-	-	Y	WW	PCPL
1	1S1	72	16	SP	230	N	5	-	-	Y	WW	PCPL
1	2	72	16	SP	230	N	15	-	-	Y	WW	PCPL
1	3	4	4	SP	230	N	15	-	-	N	WW	PCPL
1	4	72	16	SP	240	N	15	-	-	Y	WW	PCPL
1	5	72	16	CST	230	N	15	-	-	Y	WW	PCPL
1	6	72	16	SP	230	N	15	-	-	Y	WW	PSP
2A	7	72	16	SP	230	N	15	RPV	0	Y	WW	PCPL
	7dw	72	16	SP	230	N	15	RPV	0	Y	DW	PCPL
2A	10	72	16	SP	230	N	15	RPV	500	Y	WW/DW	PCPL
2A	11	72	16	SP	230	Y	15	RPV	500	Y	WW/DW	PCPL
2D	8	72	16	SP	230	N	15	RPV	<500	Y	WW	PCPL
2D	9	72	16	SP	230	Y	15	RPV	<500	Y	WW	PCPL
2D	12	72	16	SP	230	N	15	RPV	<500	Y	WW	PSP
2D	13	72	16	CST	230	N	15	RPV	<500	Y	WW	PCPL
2B	14	72	16	SP	230	N	15	RPV	0	Y	WW	PCPL
2C	15	72	16	SP	230	N	15	RPV	<500	Y	WW	PCPL
2B	18	72	16	SP	230	N	15	RPV	500	Y	WW/DW	PCPL
2B	16	72	16	SP	230	N	15	RPV	500	Y	WW/DW	PCPL
3A	21	72	16	SP	230	N	15	DW	0	Y	WW	PCPL
3A	24	72	16	SP	230	N	15	DW	500	Y	WW/DW	PCPL
	24dw	72	16	SP	230	N	15	DW	500	Y	DW	PCPL
3D	22	72	16	SP	230	N	15	DW	<500	Y	WW	PCPL
	22dw	72	16	SP	230	N	15	DW	<500	Y	DW	PCPL
3B	27	72	16	SP	230	N	15	DW	0	Y	WW	PCPL
3C	28	72	16	SP	230	N	15	DW	<500	Y	WW	PCPL
3B	32	72	16	SP	230	N	15	DW	500	Y	WW/DW	PCPL
3B	30	72	16	SP	230	N	15	DW	500	Y	WW/DW	PCPL
2A	41	4	4	SP	230	N	15	RPV	0	N	WW	PCPL
3A	43	4	4	SP	230	N	15	DW	0	N	WW	PCPL
2A	42	4	4	SP	230	N	15	RPV	500	N	WW/DW	PCPL
3A	44	4	4	SP	230	N	15	DW	500	N	WW/DW	PCPL
2D	47	4	4	SP	230	N	15	RPV	<500	Y	WW	PCPL
3D	48	4	4	SP	230	N	15	DW	<500	Y	WW	PCPL
3A	45	-	16	SP	230	-	-	DW	500	Y	DW	PCPL
3A	46	-	16	SP	230	-	-	DW	500	Y	WW/DW	PCPL
3A	49	-	0	-	-	-	-	DW	500	Y	WW/DW	PCPL
3B	50	-	0	-	-	-	-	DW	500	Y	WW/DW	PCPL
3A	51	-	16	SP	230	-	15	DW	500	Y	DW	15
3A	52	-	16	SP	230	-	15	DW	500	N	DW	15
3A	53	-	16	SP	230	-	15	DW	500	Y	DW	15

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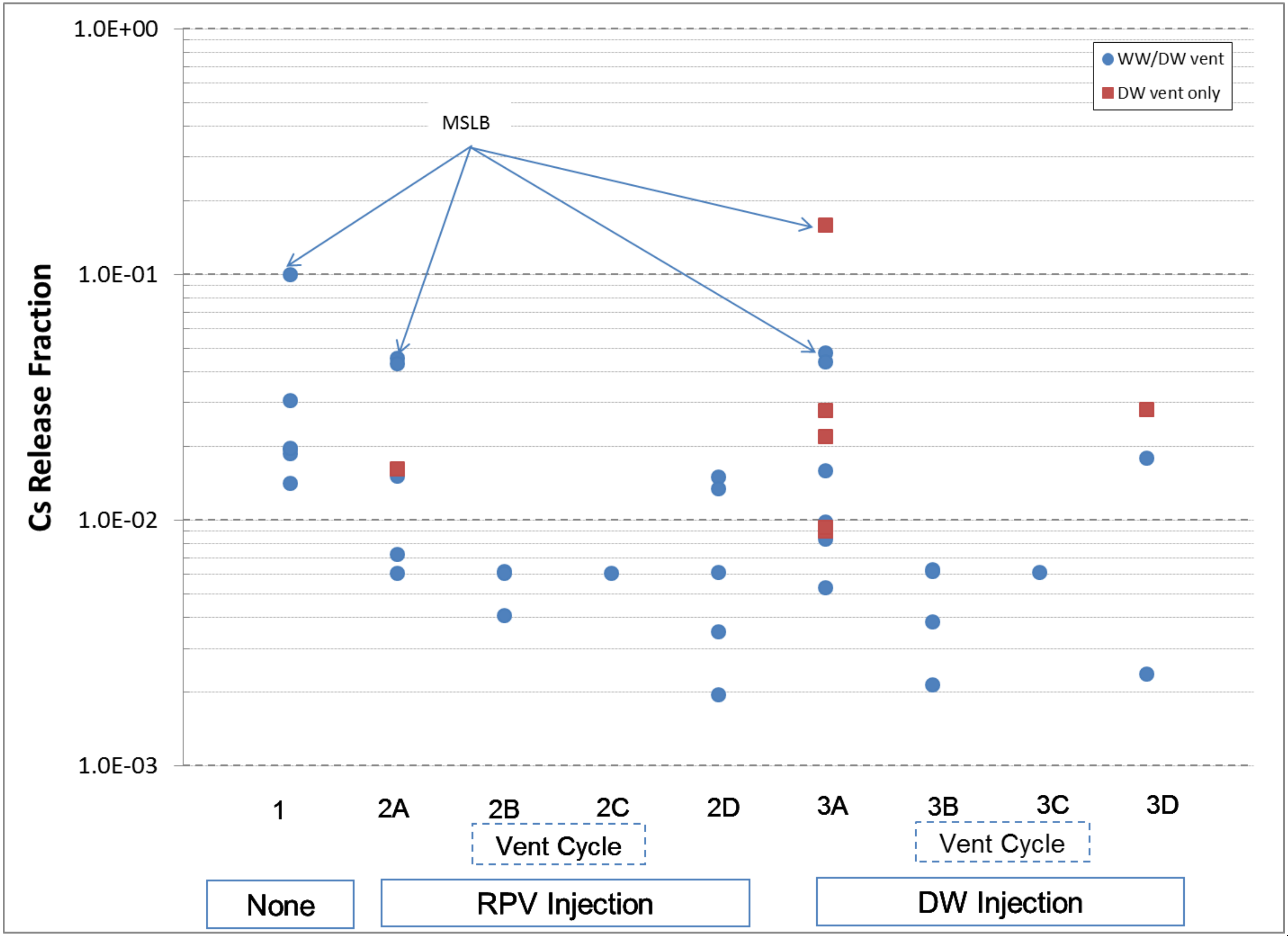
MELCOR Run Matrix for Mark II

- **Same initial and boundary conditions as for Mark I analysis**
- **Run matrix condensed compared to Mark I analysis (e.g., vent cycling cases not considered)**
- **Sensitivities to containment design**

			Pre Core Damage					Post Core Damage				
		RPV Pressure control	RCIC Operation				Anticipatory Venting	Flex Operation		SRV Operation	Venting	
		Availability (hr)	RCIC Availability (hr)	RCIC Suction	Failure Temp (F)	Open SRV after RCIC fails	Setpoint (psig)	Injection @ LH failure	WW Level Control Injection @ 21' (gpm)	Allow SRV stuck open failure?	Location	Setpoint
Option	Case											
1	1	72	16	SP	230	N	15	-	-	Y	WW	PCPL
1	3	4	4	SP	230	N	15	-	-	N	WW	PCPL
1	5	72	16	CST	230	N	15	-	-	Y	WW	PCPL
2A	10	72	16	SP	230	N	15	RPV	500	Y	WW/DW	PCPL
2A	11	72	16	SP	230	Y	15	RPV	500	Y	WW/DW	PCPL
3A	24	72	16	SP	230	N	15	DW	500	Y	WW/DW	PCPL
2A	42	4	4	SP	230	N	15	RPV	500	N	WW/DW	PCPL
3A	44	4	4	SP	230	N	15	DW	500	N	WW/DW	PCPL
3A	45	-	16	SP	230	-	-	DW	500	Y	DW	PCPL
3A	49	-	0	-	-	-	-	DW	500	Y	WW/DW	PCPL
3A	51	-	16	SP	230	-	15	DW	500	Y	DW	15
3A	52	-	16	SP	230	-	15	DW	500	N	DW	15

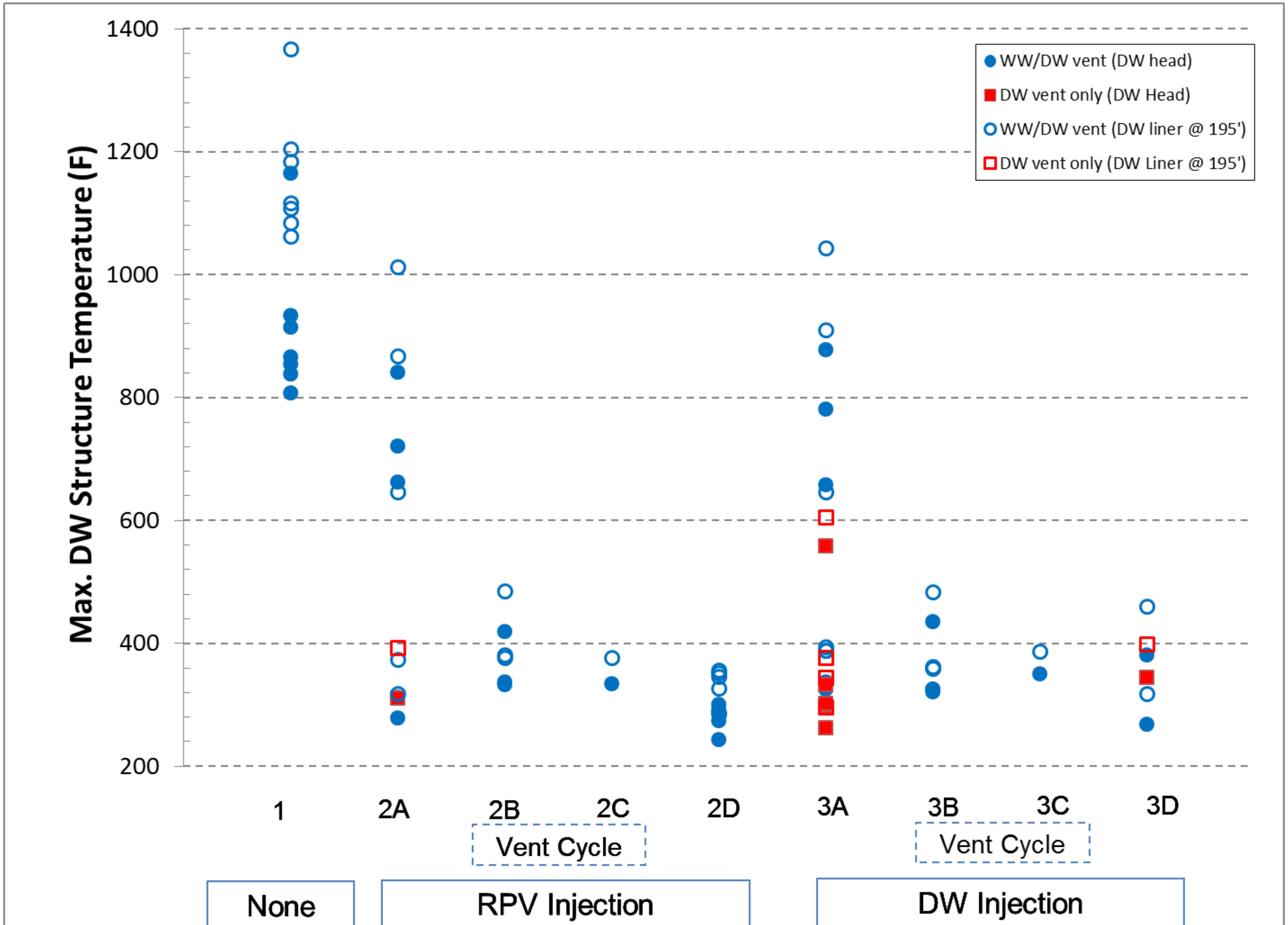
MELCOR Results for Mark I

(Cs release fraction)



MELCOR Results for Mark I

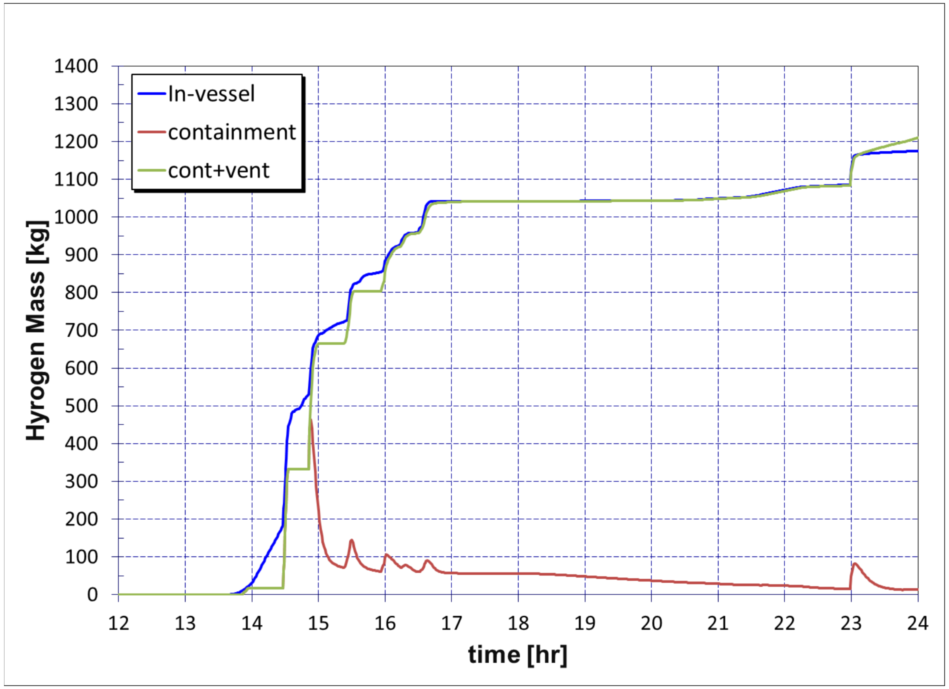
(DW structure temperature)



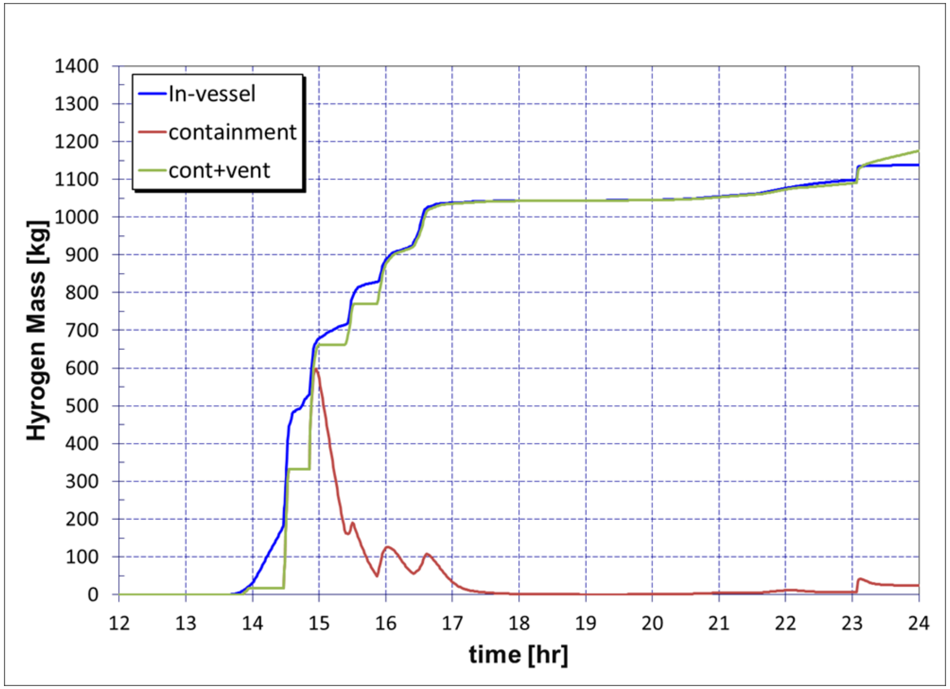
MELCOR Results for Mark I

(hydrogen mass)

Case 7: WW venting



Case 7dw: DW venting



The blue line represents the total hydrogen generation in-vessel. The green line represents the total hydrogen inside the containment and the amount vented to the atmosphere (the step increases are due to SRV cycling). The red line is the amount of hydrogen remaining inside the containment that starts to decrease at the time of venting (14.9 hours).

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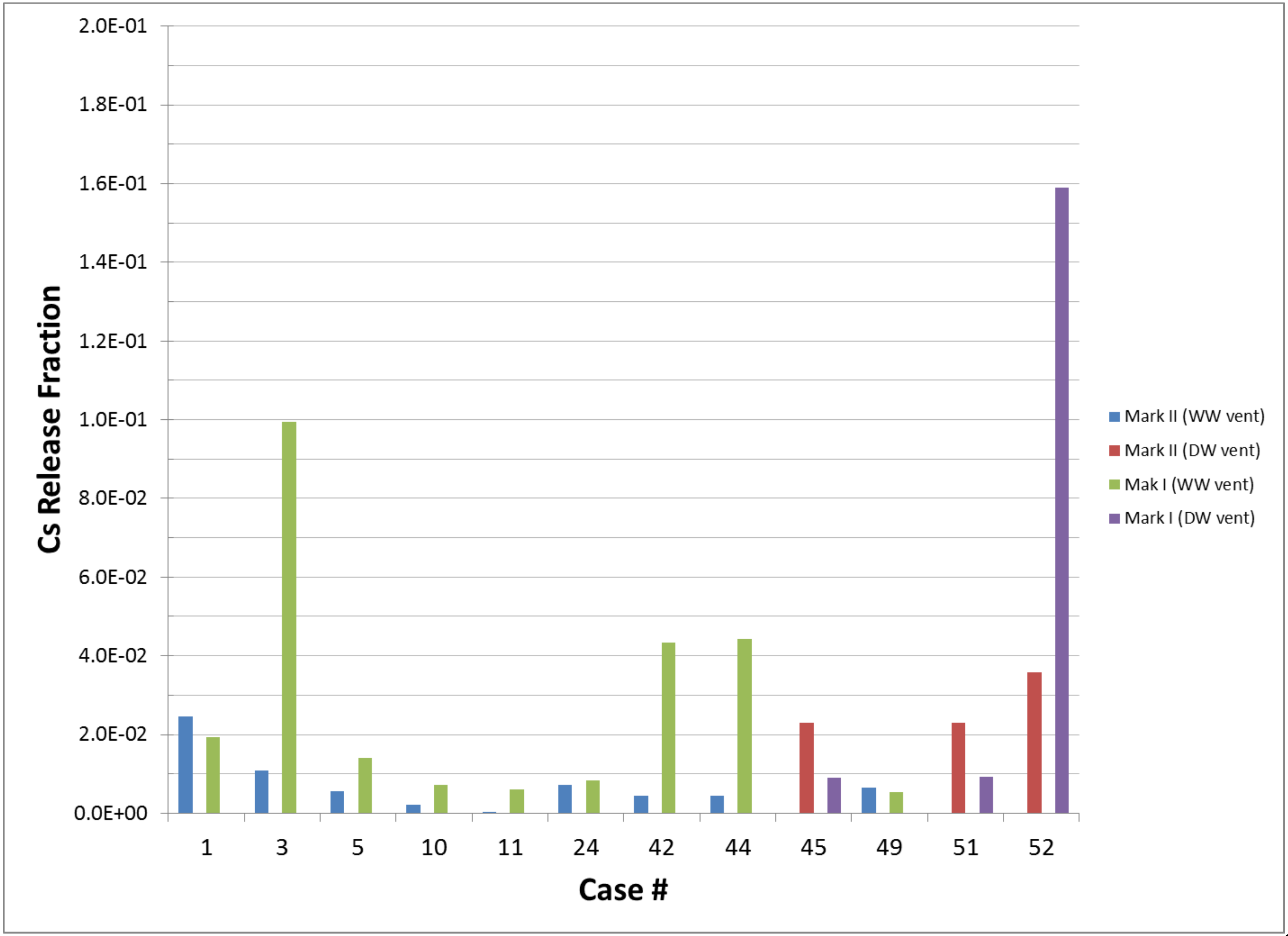
MELCOR Results for Mark II

(Cs release fraction)



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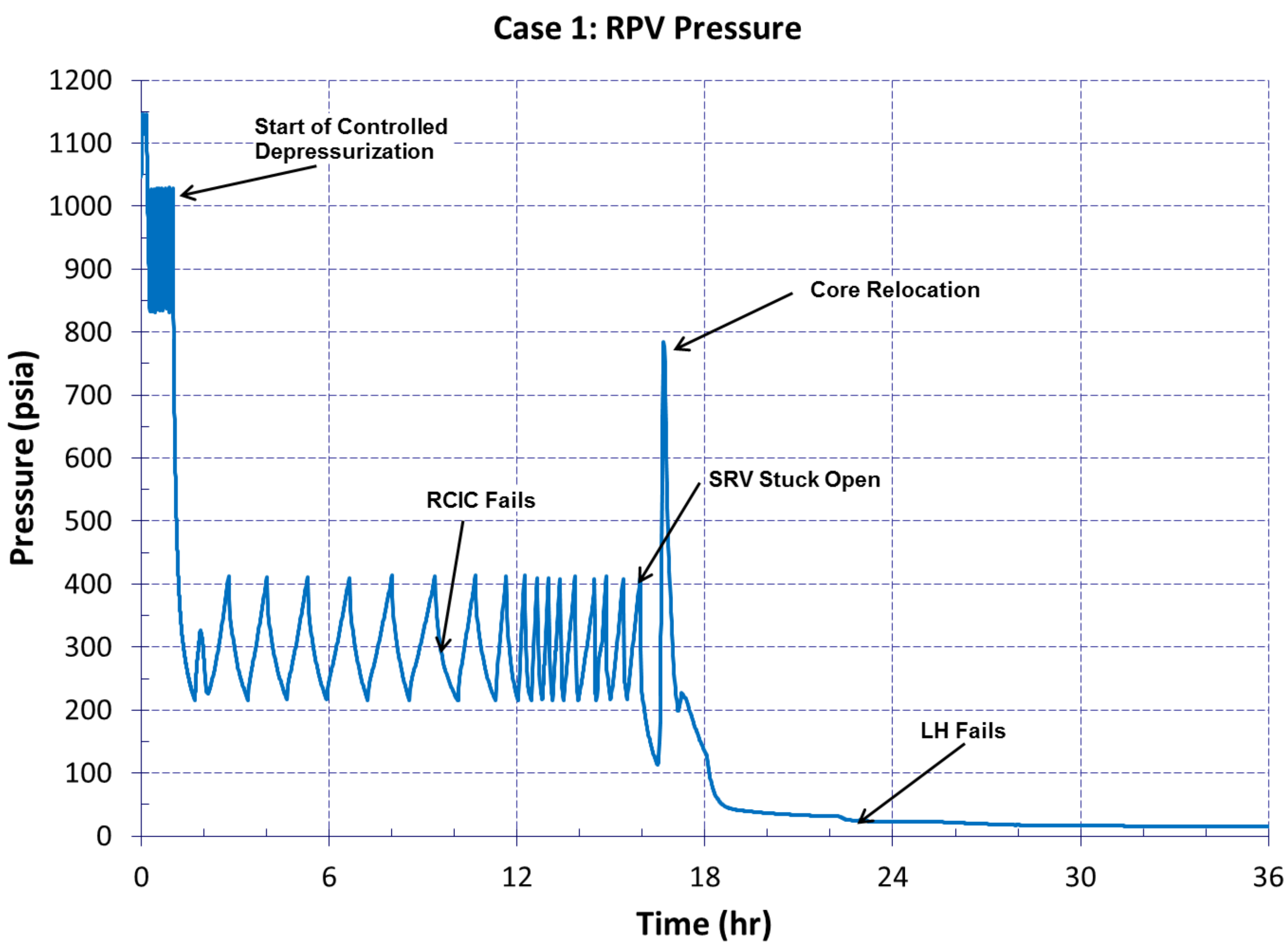
BACKUP

MELCOR Results for Mark I

(RPV pressure response)



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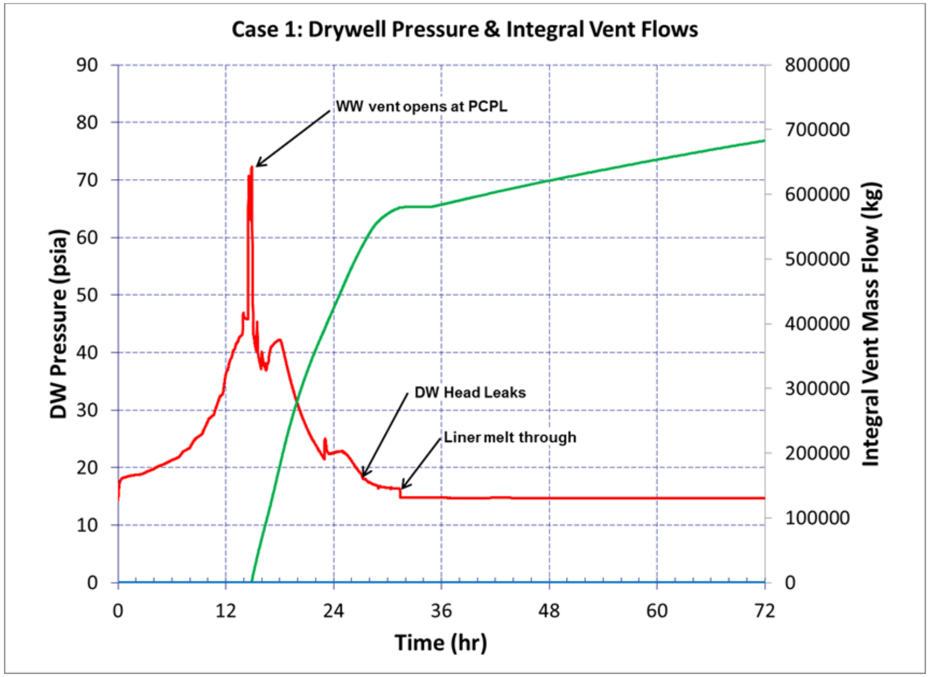
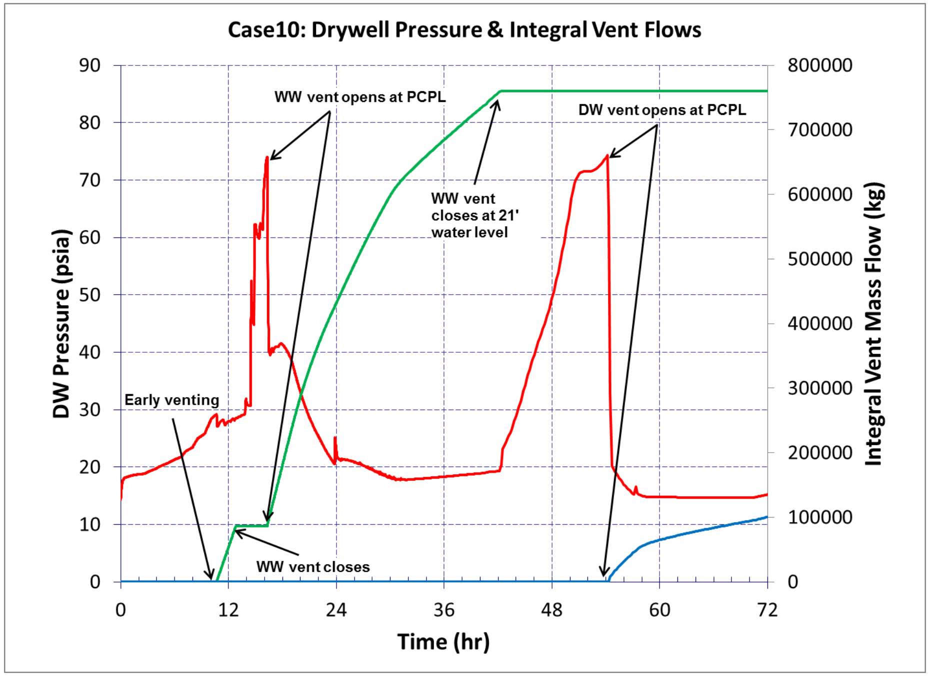
MELCOR Results for Mark I

(containment pressure response)

Case 1: No injection



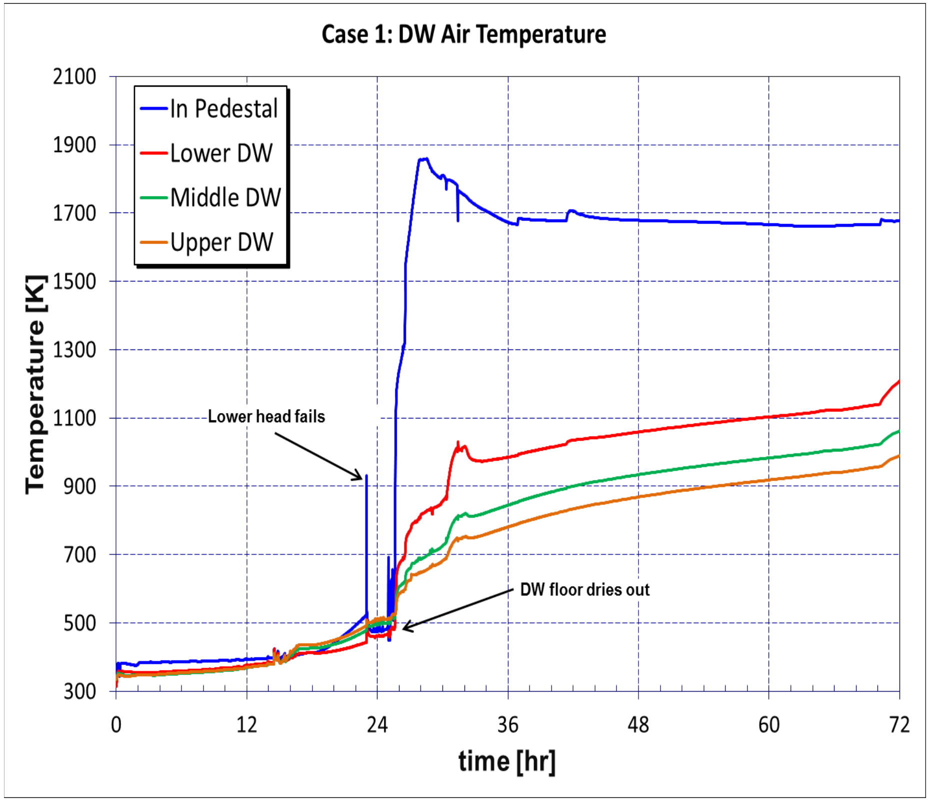
Case 10: RPV injection



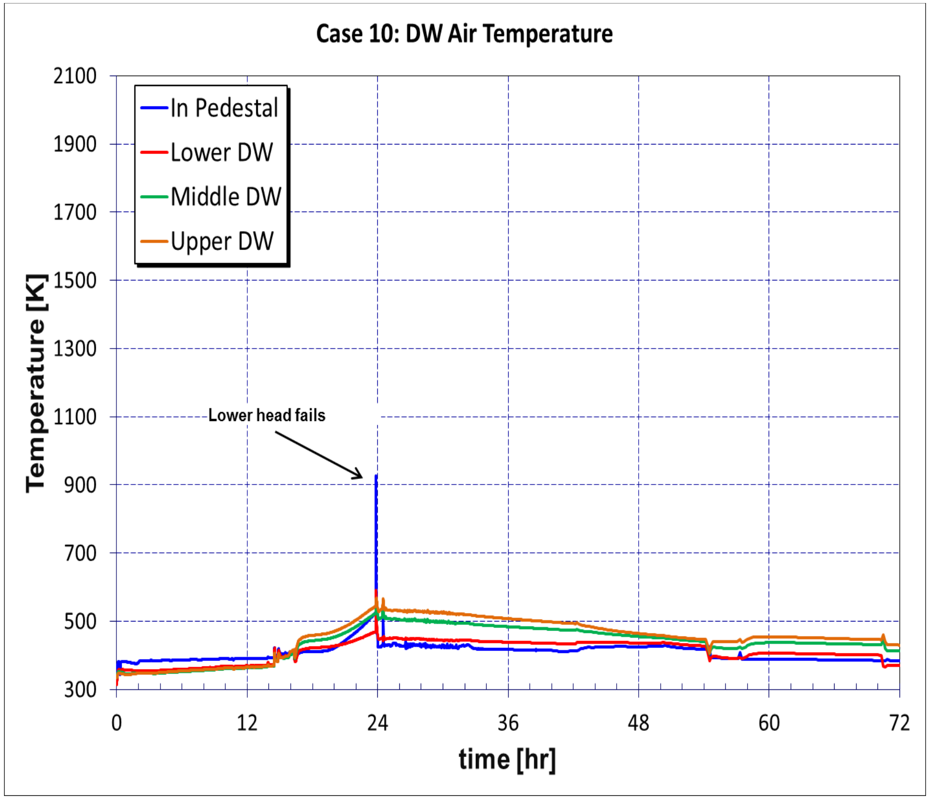
MELCOR Results for Mark I

(containment temperature response)

Case 1: No injection



Case 10: RPV injection



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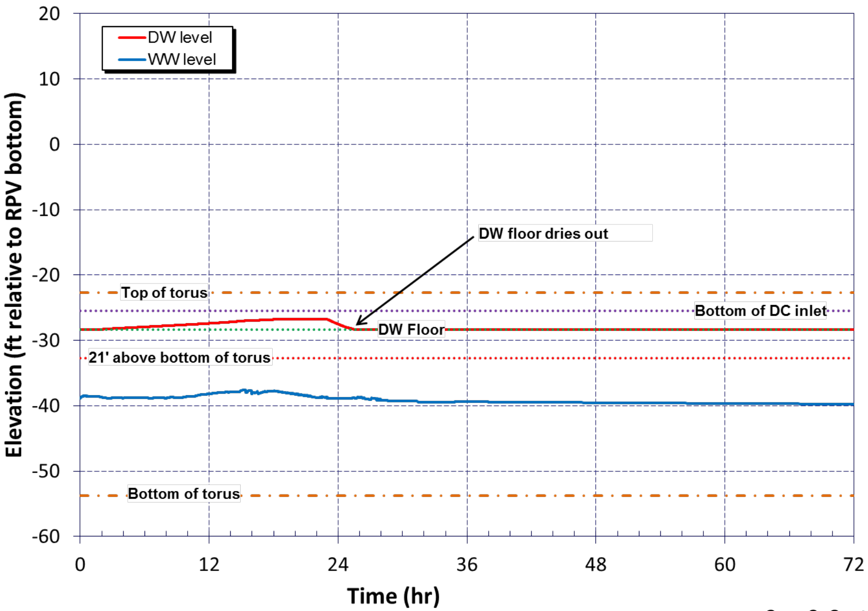
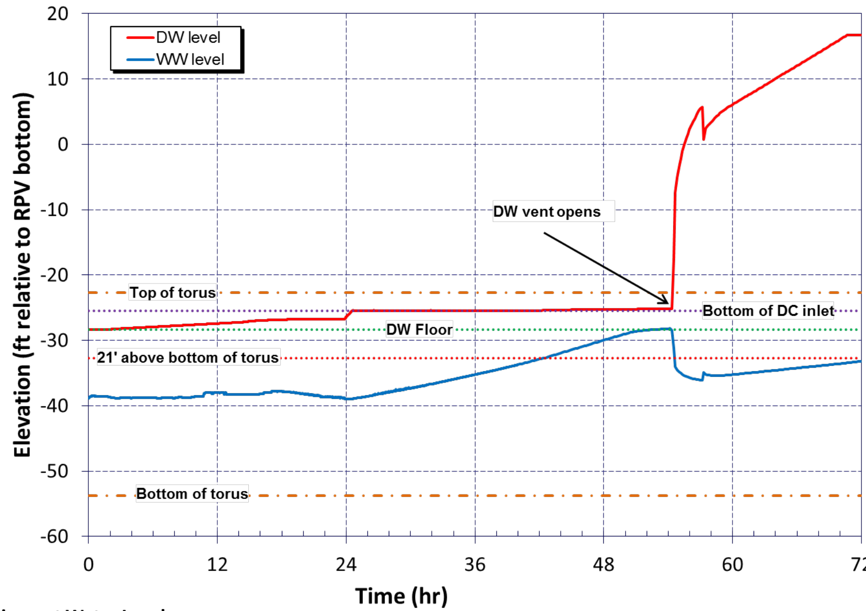
MELCOR Results for Mark I
(containment water level response)

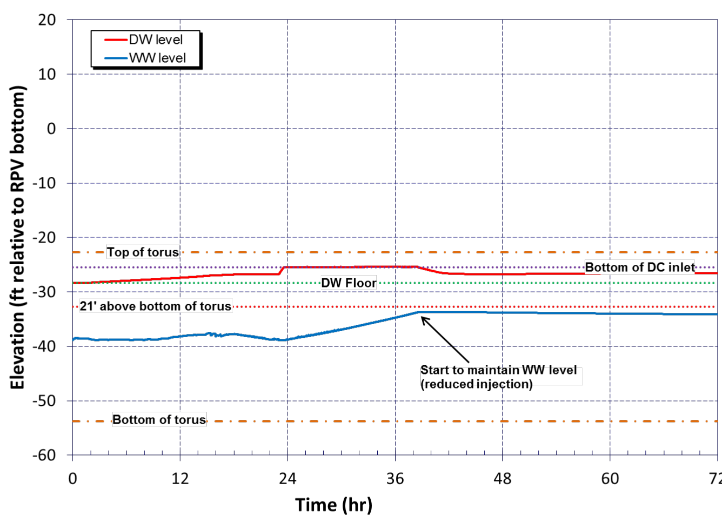
Case 1: Containment Water Level



Case 10: Containment Water Level



Case 8: Containment Water Level



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Filtering Strategies Rulemaking Technical Evaluation

Rick Wachowiak (EPRI): EPRI Project Manager
Jeff Gabor (ERIN): Investigator
Doug True (ERIN): Investigator
David Luxat (ERIN): Investigator

Advisory Committee on Reactor Safeguards
August 22, 2014

Overview

- Industry Filtering Strategies
  - Managing the Accident
  - The Importance of Water Addition

- Technical Evaluation and Supporting Analysis
  - Mark I Analysis and Results
  - Mark II Analysis Approach

Filtering Strategies Rulemaking

- Industry has always viewed the Mark I/II containment issue in the context of accident management
  - Response to postulated severe accidents like the accidents at Fukushima requires operator action
- Accident management involves:
  - Cooling core debris
  - Managing decay heat
  - Mitigating releases
- Evaluation of the residual benefits of filtering strategies should be made in the context of an effective accident management capability and focused on the dominant accident scenarios

Filtering Strategies Rulemaking (Cont.)

- Objectives of Industry Technical Evaluation:
  - Understand the role FLEX plays in ELAP mitigation
  - Understand dominant severe accident scenarios
  - Develop clear, manageable analysis of filtering strategy alternatives
  - Support open dialog with NRC staff on assumptions, technical issues, and insights
  - Inform the implementation of EA 13-109 (to the extent feasible)
  - Provide insights to BWROG on EPG/SAGs
  - Support industry decision-makers on the cost-benefit considerations

Overall Status

- Completing Evaluation of BWR Mark I Containments
  - Baseline evaluation of alternatives for reference plant
  - Sensitivity analyses next

- Preparing for Evaluation of Mark II Containments
  - Analysis approach defined
  - Using BWR data collected for NRC
  - May require more than one reference plant

Insights to Date

- Operator actions are essential to management of accident
  - Both pre- and post-core damage
- FLEX provides substantial safety benefit
- Water addition a key to severe accident management
  - Without water addition, safety benefit of severe accident vent is lost
  - Water addition via RPV preferred
- Other filtering strategies can reduce releases, but no substantial benefit for dominant scenarios
- Mark II response may be somewhat different than Mark I
  - Water addition still key to severe accident management

Value of Water Addition

- Preserve containment boundary
  - Avoid liner melt-through
- Reduce containment temperatures
  - Reduce thermal challenges
- Reduce airborne fission products
  - Debris cooling reduces airborne aerosols

NRC Accepted Industry Recommendation to Include Safety Benefit of Water Addition Under Phase 2 of Order

Terminology

- Severe Accident Water Addition (SAWA)
  - Providing water to reactor vessel or drywell post-core damage.

- Severe Accident Water Management (SAWM)
  - Preserve wetwell vent path.

Industry Developing Phase 2
Guidance for Both SAWA & SAWM

Framework for Industry Technical Evaluation of Mark I Filtering Strategies

(Preliminary Results)

General Approach

- Build off of SECY-12-0157 methodology using SOARCA reference plant
- Align assumptions with NRC assessment as much as possible
- Explicit analysis of all scenarios
- Consider risk and Defense in Depth
- Support NEI cost-benefit analysis
- Address spectrum of sensitivities

Elements of Alternatives

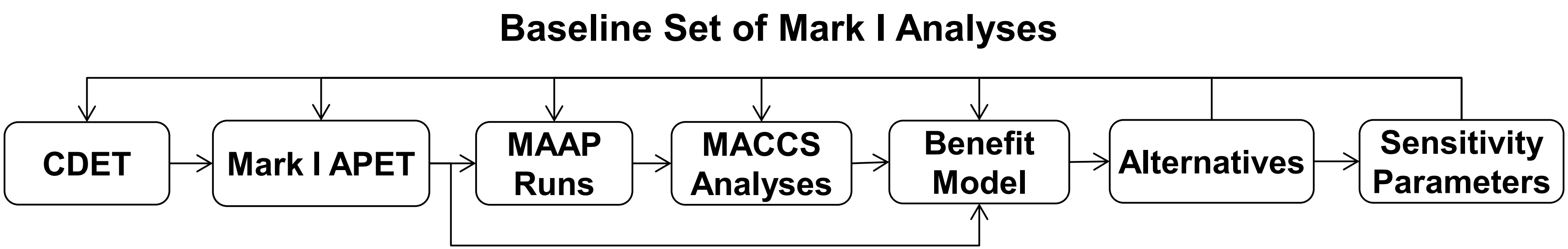
- Base Case:
  - FLEX implemented
  - Rev. 3 EPG/SAGs implemented
  - Severe Accident Capable Wetwell Vent per EA 13-109 Phase 1
- Alternative dimensions
  - Severe accident capable DW vent
  - SAWA to the RPV
  - SAWA to DW
  - SAWM (avoid need for DW vent)
  - Vent Control (within 20 psig pressure band)
  - Small Filter
  - Large Filter

Summary of Alternative Cases

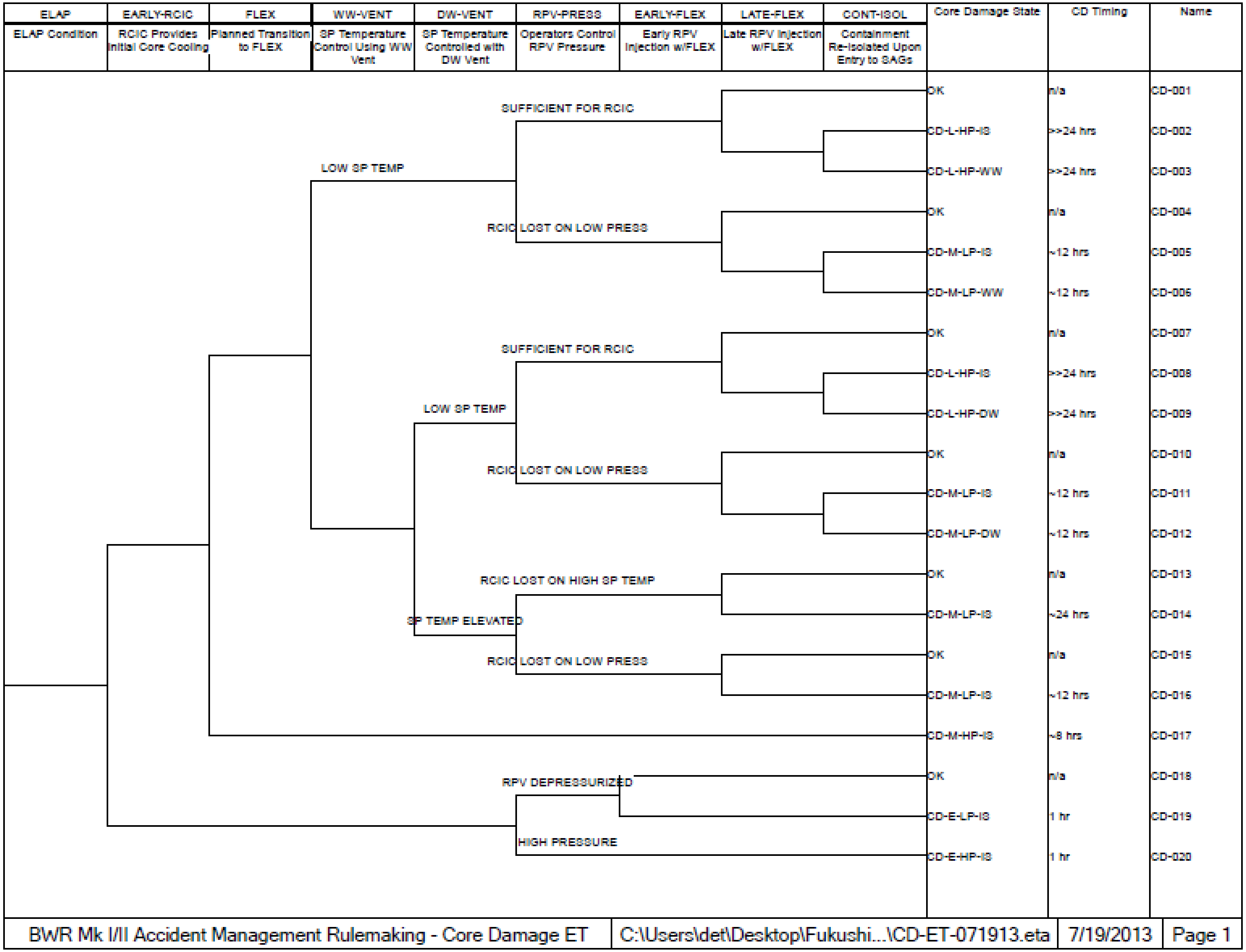
Alternative	SAC WW Vent	DW Vent	SAWA	SAWM	Vent Control	Filter	Filter Path
New Base	Yes	None	No	No	No	None	Manual
1A	Yes	SACV	No	No	No	None	Manual
2A	Yes	None	RPV	No	No	None	Manual
2B	Yes	None	RPV	**Yes**	No	None	Manual
2C	Yes	None	RPV	No	**Yes**	None	Manual
2D	Yes	None	RPV	**Yes**	**Yes**	None	Manual
2E	Yes	SACV	RPV	No	No	None	Manual
2F	Yes	SACV	RPV	**Yes**	No	None	Manual
2G	Yes	SACV	RPV	No	**Yes**	None	Manual
2H	Yes	SACV	RPV	**Yes**	**Yes**	None	Manual
3A	Yes	None	DW	No	No	None	Manual
3B	Yes	None	DW	**Yes**	No	None	Manual
3C	Yes	None	DW	No	**Yes**	None	Manual
3D	Yes	None	DW	**Yes**	**Yes**	None	Manual
3E	Yes	SACV	DW	No	No	None	Manual
3F	Yes	SACV	DW	**Yes**	No	None	Manual
3G	Yes	SACV	DW	No	**Yes**	None	Manual
3H	Yes	SACV	DW	**Yes**	**Yes**	None	Manual
4A	Yes	SACV	RPV	No	No	**Small**	Manual
4B	Yes	SACV	DW	No	No	**Small**	Manual
5A	Yes	SACV	RPV	No	No	**Large**	Manual
5B	Yes	SACV	DW	No	No	**Large**	Manual
6A	Yes	SACV	DW	No	No	**Large**	**All Passive**
6B	Yes	SACV	DW	No	No	**Large**	**Manual Pre-CD**

Legend
No SAWA
RPV SAWA
DW SAWA

EPRI Analysis Framework



Core Damage Scenario Development



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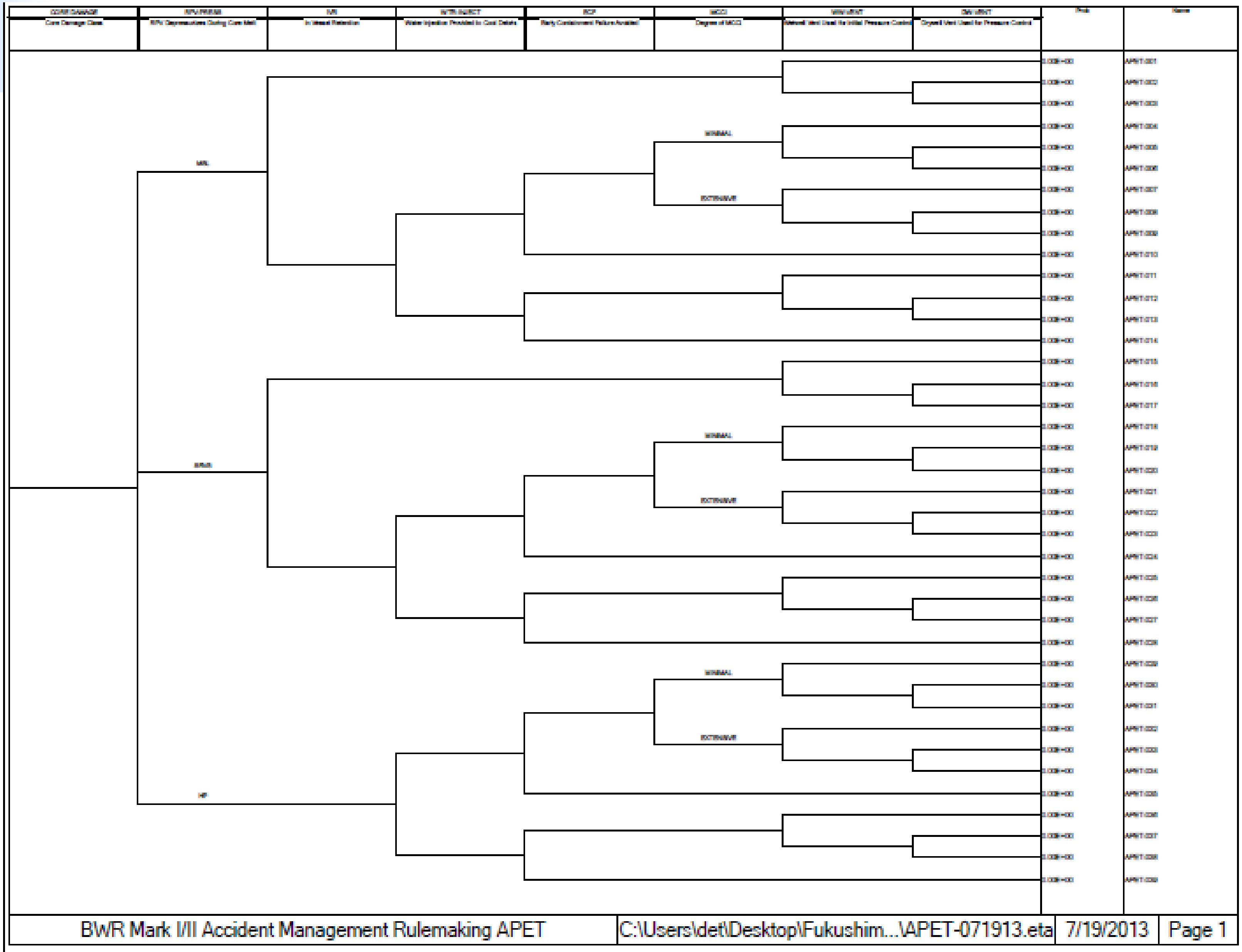
Core Damage Top Events

- ELAP
  - Total loss of offsite and onsite AC power
- EARLY-RCIC
  - RCIC available to operate initially
- FLEX
  - FLEX implementation successful for injection pump and DC power for pressure control
- WW-VENT
  - Wetwell vent successful for extended RCIC operation
- DW-VENT
  - Drywell vent successful for extended RCIC operation
- RPV-PRESS
  - Operators successfully control RPV pressure to extend RCIC operation
- EARLY-FLEX
  - For scenarios with failure of EARLY-RCIC, FLEX implementation to prevent core damage
- LATE-FLEX
  - For scenarios with success of EARLY-RCIC and FLEX, FLEX implementation late after loss of RCIC able to prevent core damage
- CONT-ISOL
  - If venting was performed prior to core damage, this node addresses the successful closure of that vent path upon entry into the SAGs

Accident Progression Event Tree



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APET Top Events

- RPV-PRESS
  - This node addresses the potential for either an SRV seizing open or creep rupture of the main steam line during the core damage phase of the accident. The split fractions will be influenced by the entry condition for RPV pressure as defined by the core damage state.
- IVR
  - Should injection be provided to the RPV after the onset of core damage but prior to vessel breach, there is some likelihood that vessel breach can be avoided.
- WTR-INJECT
  - Water injection into the RPV or into the drywell is considered here. The injection is either available prior to vessel breach or following vessel breach. Defined by alternative being considered.
- ECF
  - This event evaluates the potential for early drywell failure as a result of vessel breach and the discharge of core material into containment. Without water injection, the likelihood of liner melt through (LMT) is considered high. This node can also address the potential for containment failure resulting from high pressure melt ejection.
- MCCI
  - For cases with successful injection of water into containment, this event evaluates the potential for core debris quenching, thereby stopping the molten core concrete interaction.
- WW-VENT
  - Wetwell venting is initially used for containment pressure control (Later DW venting assumed after WW vent isolation per SAGs)
- DW-VENT
  - If the wetwell vent fails to operate, the drywell vent will be used for containment pressure control.

Major Contributors to Core Damage

36% - RCIC Fails Early, No ED, FLEX ineffective

26% - RCIC Succeeds Early, FLEX late/unavailable

23% - RCIC Fails Early, ED Success, FLEX late/unavailable

8% - RCIC Succeeds Early (0-6 hrs), FLEX initially succeeds, but fails on high SP temp (no venting), ED

3% - RCIC & Early WW Venting Succeeds, RCIC & FLEX fail late, Cont. Re-isolated

2% - RCIC & Early WW Venting Succeeds, RCIC lost late due to failed RPV pressure control, FLEX Fails, Cont. Re-Isolated

~ 99% of total CDF

Preliminary results

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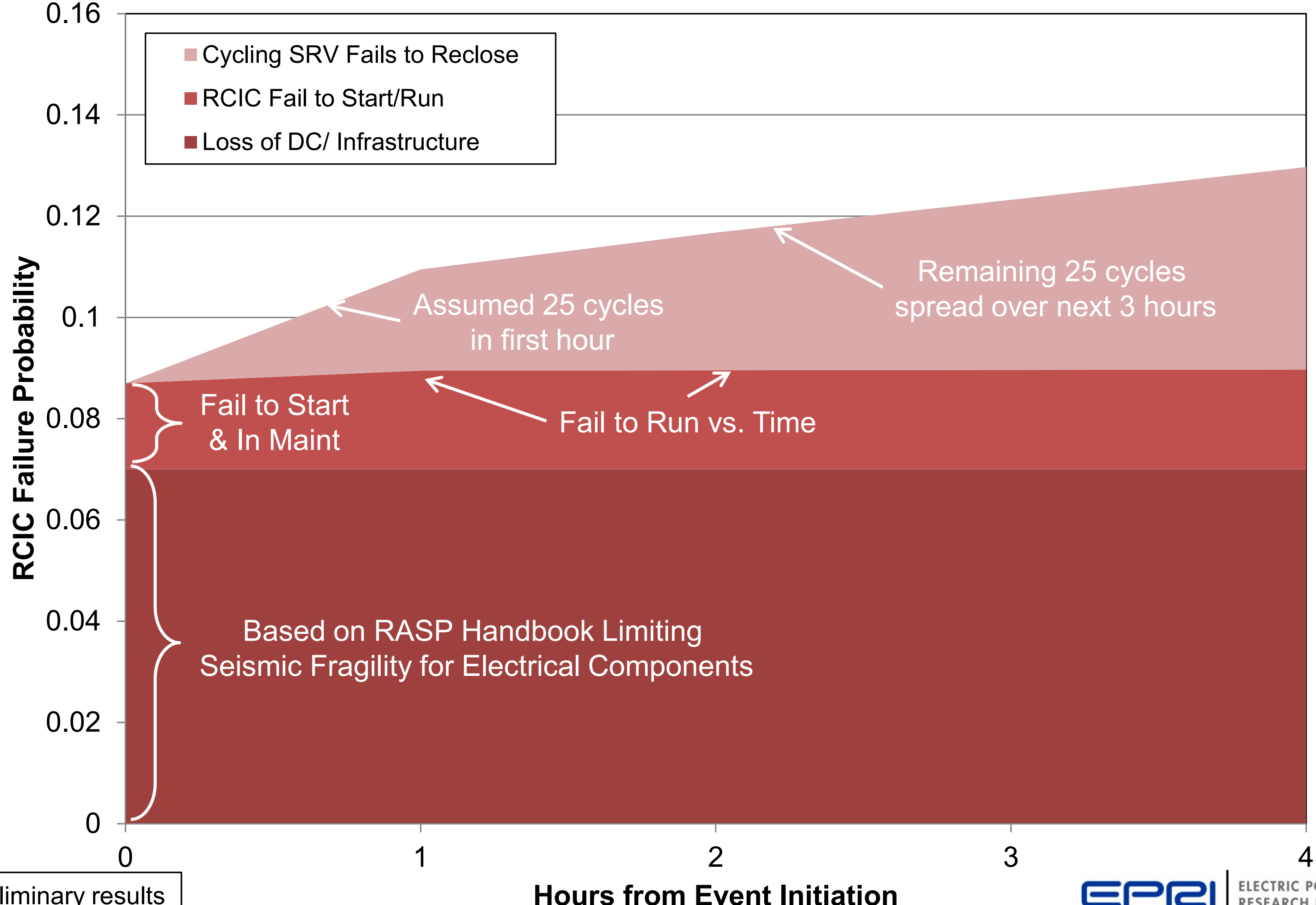
Contributors to RCIC Failure vs. Time (0-4 hrs)



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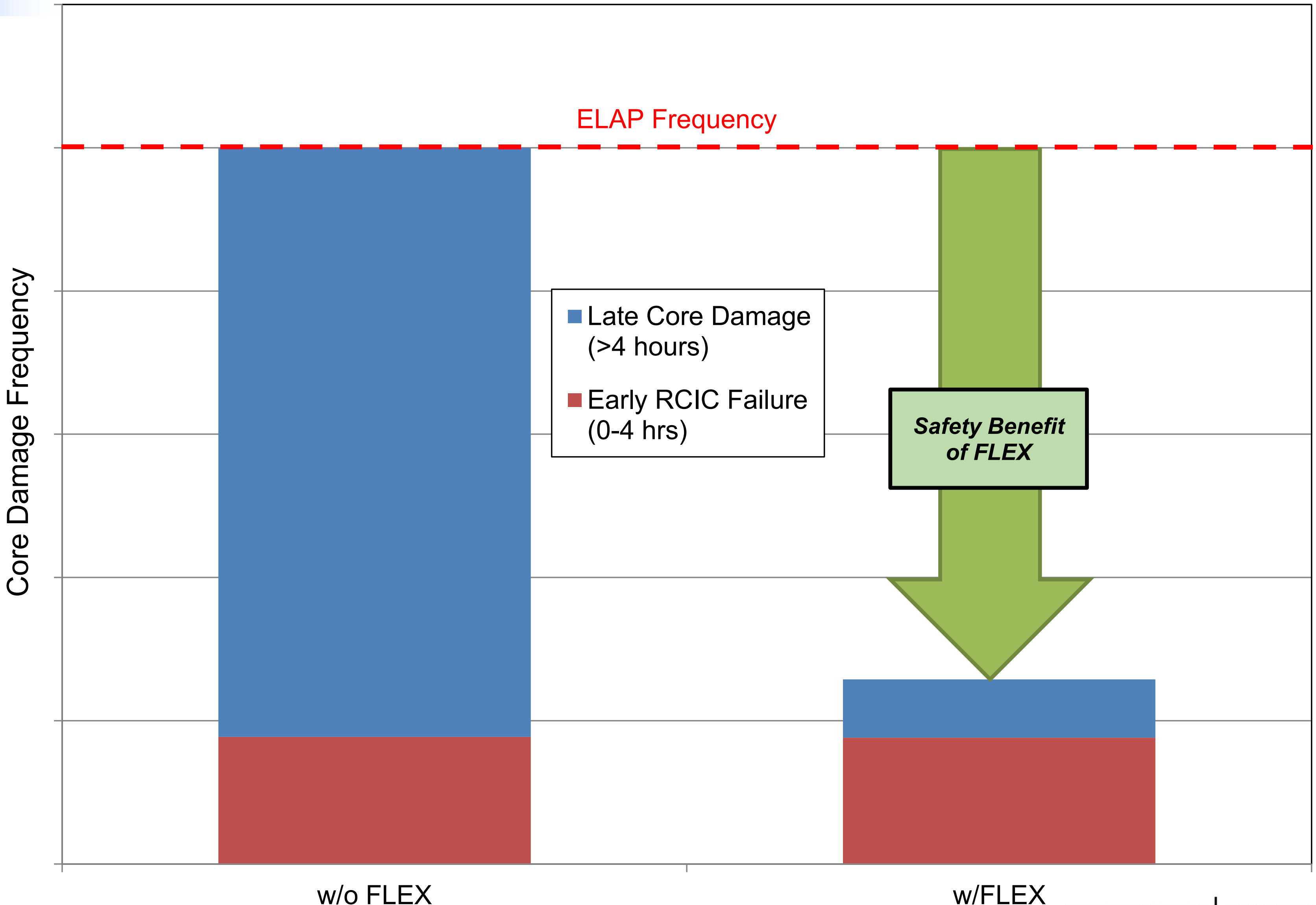
Influence of FLEX on ELAP Core Damage Contributors



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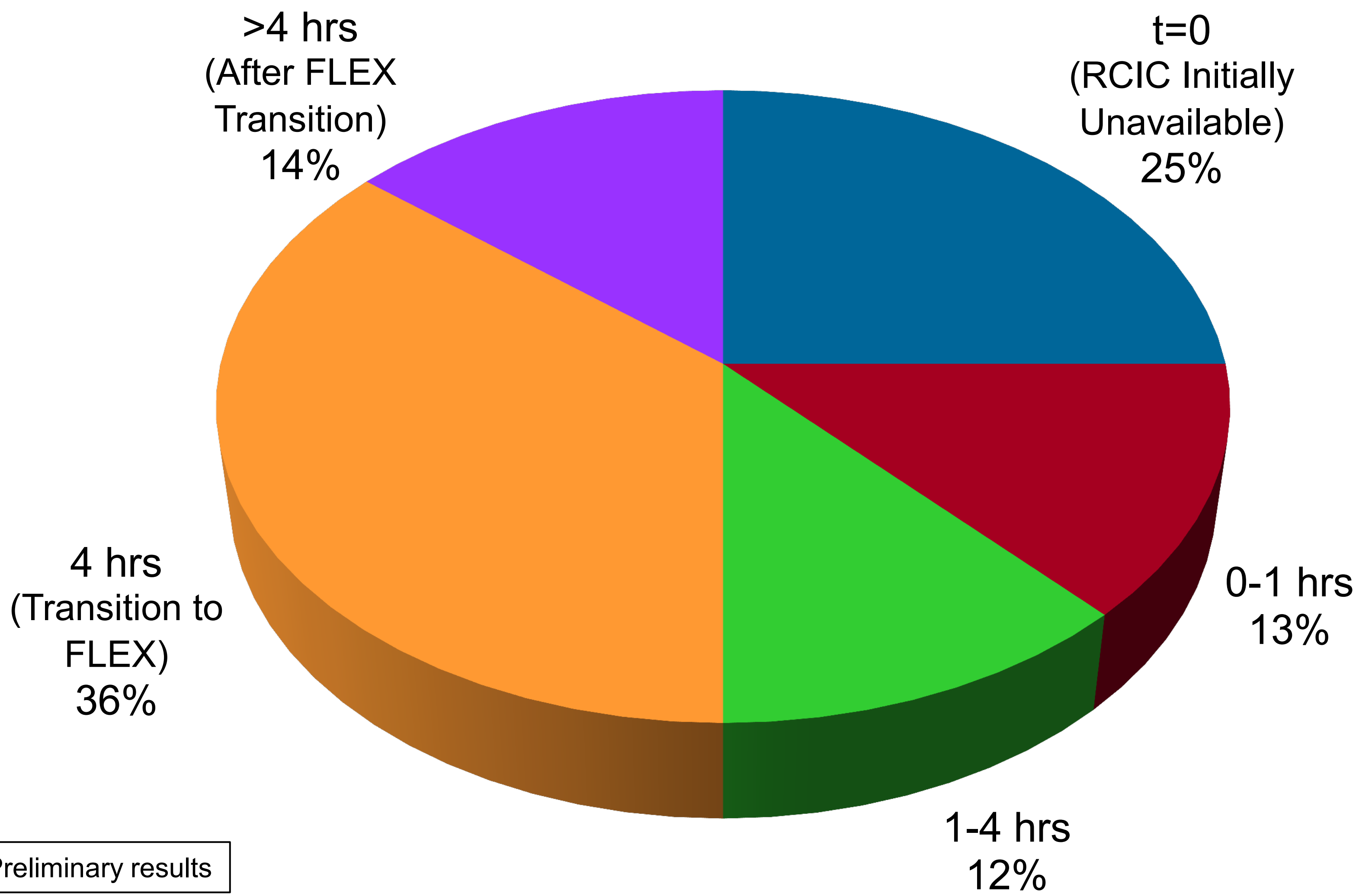
Timing of Loss of Core Cooling



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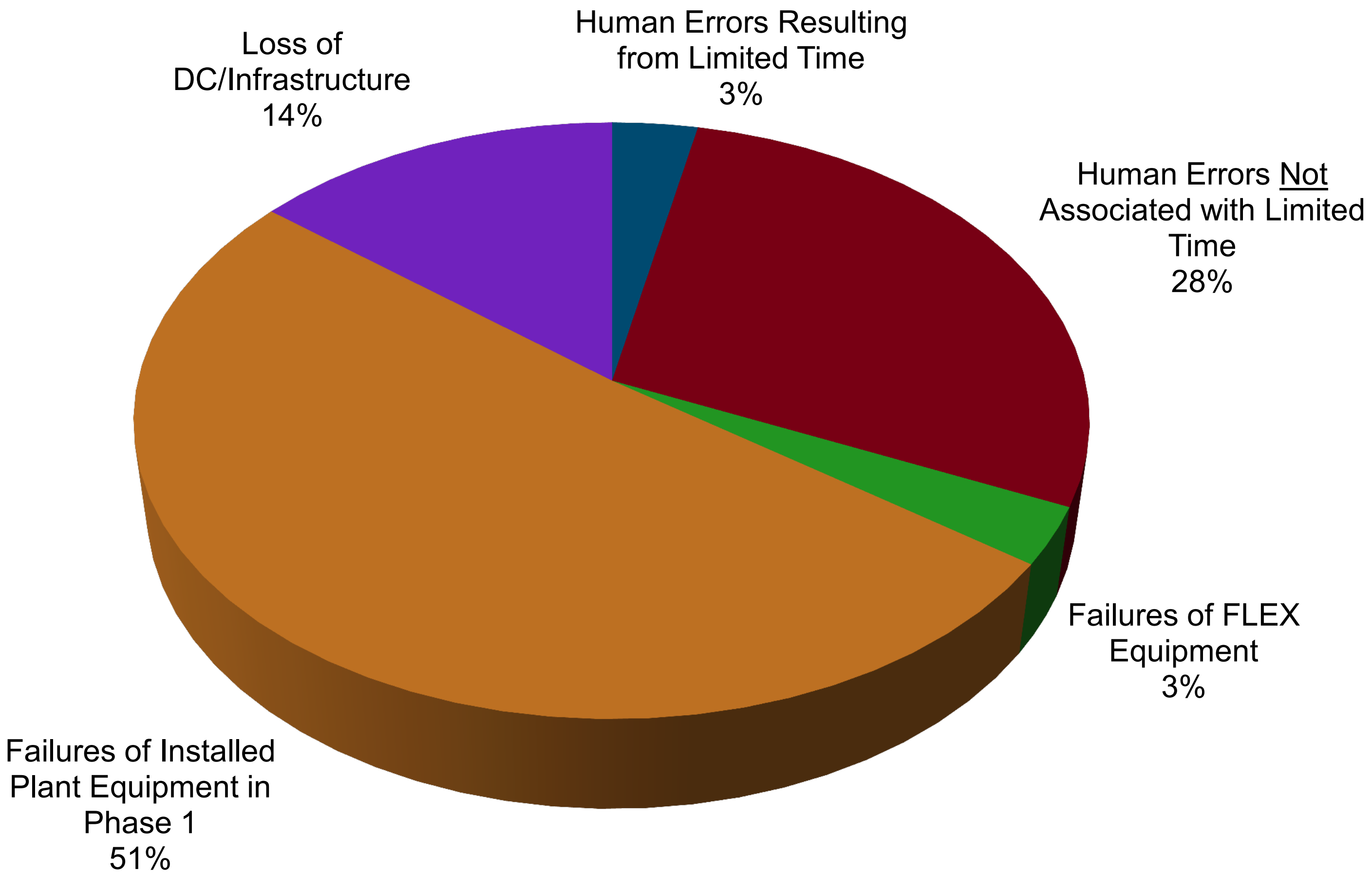
Contributors to Core Damage



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Dominant APET Scenarios

- SRM requires evaluation focus on dominant severe accident scenarios
- Current industry approach to identifying dominant scenarios focuses on APET endstates that contribute more than 0.5%
- Example: SAWA to RPV results
  - A total of 29 scenarios exceed 0.5%
  - These 29 scenarios cover ~90% of core damage frequency

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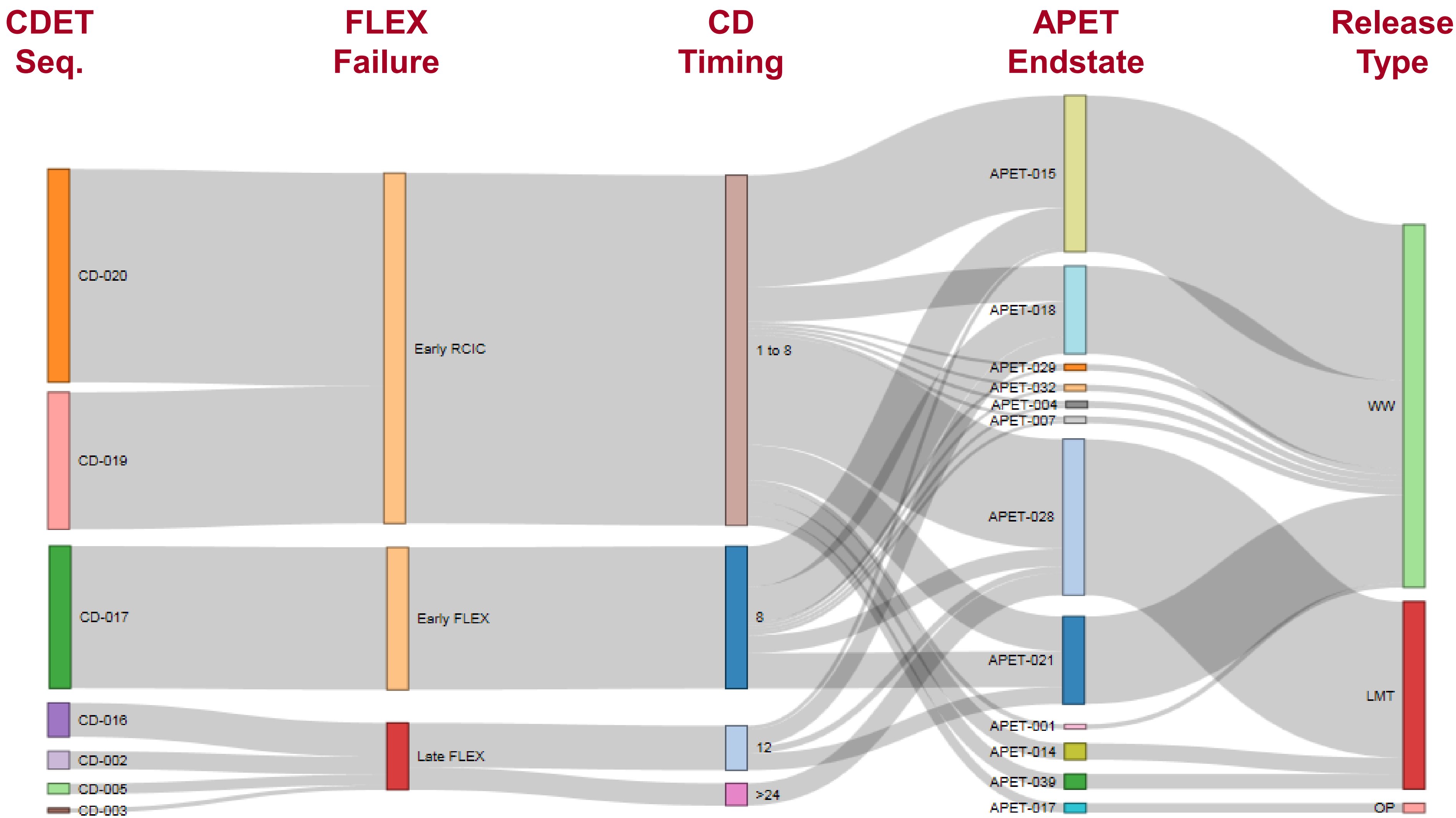
Description of Dominant APET Endstates (SAWA to RPV)

Endstate	Contrib	CDET Scenario	APET Scenario
CD-019.APET-015	19.0%	RCIC Fails Early, Operator ED, FLEX Late/Unavail	SRV Opens, Retained In-Vessel, WW Vent
CD-017.APET-015	9.3%	RCIC Succeeds Early (0-6 hrs), FLEX Late/Unavail	SRV Opens, Retained In-Vessel, WW Vent
CD-017.APET-018	8.2%	RCIC Succeeds Early (0-6 hrs), FLEX Late/Unavail	SRV Opens, Ex-Vessel Debris, Water Injected, Minimal CCI, WW Vent
CD-017.APET-021	8.2%	RCIC Succeeds Early (0-6 hrs), FLEX Late/Unavail	SRV Opens, Ex-Vessel Debris, Water Injected, Extensive CCI, WW Vent
CD-019.APET-028	6.4%	RCIC Fails Early, Operator ED, FLEX Late/Unavail	SRV Opens, Ex-Vessel Debris, No Water Injected, LMT Occurs
CD-019.APET-018	4.3%	RCIC Fails Early, Operator ED, FLEX Late/Unavail	SRV Opens, Ex-Vessel Debris, Water Injected, Minimal CCI, WW Vent
CD-019.APET-021	4.3%	RCIC Fails Early, Operator ED, FLEX Late/Unavail	SRV Opens, Ex-Vessel Debris, Water Injected, Extensive CCI, WW Vent
CD-017.APET-028	4.0%	RCIC Succeeds Early (0-6 hrs), FLEX Late/Unavail	SRV Opens, Ex-Vessel Debris, No Water Injected, LMT Occurs
CD-020.APET-015	3.7%	RCIC Fails Early, No ED, FLEX ineffective	SRV Opens, Retained In-Vessel, WW Vent
CD-002.APET-028	3.7%	RCIC & Early Venting Succeed, FLEX fails late, Cont. Re-isolated	SRV Opens, Ex-Vessel Debris, No Water Injected, LMT Occurs
CD-020.APET-028	3.5%	RCIC Fails Early, No ED, FLEX ineffective	SRV Opens, Ex-Vessel Debris, No Water Injected, LMT Occurs
CD-020.APET-018	1.5%	RCIC Fails Early, No ED, FLEX ineffective	SRV Opens, Ex-Vessel Debris, Water Injected, Minimal CCI, WW Vent
CD-020.APET-021	1.5%	RCIC Fails Early, No ED, FLEX ineffective	SRV Opens, Ex-Vessel Debris, Water Injected, Extensive CCI, WW Vent
CD-016.APET-018	1.2%	RCIC Succeeds Early (0-6 hrs), FLEX Succeeds, No Venting, ED	SRV Opens, Ex-Vessel Debris, Water Injected, Minimal CCI, WW Vent
CD-016.APET-021	1.2%	RCIC Succeeds Early (0-6 hrs), FLEX Succeeds, No Venting, ED	SRV Opens, Ex-Vessel Debris, Water Injected, Extensive CCI, WW Vent
CD-003.APET-028	0.9%	RCIC & Early Venting Succeed, FLEX fails late, WW Vent Not Re-Isolated	SRV Opens, Ex-Vessel Debris, No Water Injected, LMT Occurs
CD-005.APET-015	0.8%	RCIC Lost on ED, FLEX Fails, Cont. Re-Isolated	SRV Opens, Retained In-Vessel, WW Vent
CD-017.APET-004	0.7%	RCIC Succeeds Early (0-6 hrs), FLEX Late/Unavail	MSL Occurs, Ex-Vessel Debris, Water Injected, Minimal CCI, WW Vent
CD-017.APET-007	0.7%	RCIC Succeeds Early (0-6 hrs), FLEX Late/Unavail	MSL Occurs, Ex-Vessel Debris, Water Injected, Extensive CCI, WW Vent
CD-020.APET-039	0.7%	RCIC Fails Early, No ED, FLEX ineffective	HPME Occurs, Ex-Vessel Debris, No Water Injected, LMT Occurs
CD-020.APET-014	0.7%	RCIC Fails Early, No ED, FLEX ineffective	MSL Occurs, Ex-Vessel Debris, No Water Injected, LMT Occurs
CD-017.APET-029	0.7%	RCIC Succeeds Early (0-6 hrs), FLEX Late/Unavail	HPME Occurs, Ex-Vessel Debris, Water Injected, Minimal CCI, WW Vent
CD-017.APET-032	0.7%	RCIC Succeeds Early (0-6 hrs), FLEX Late/Unavail	HPME Occurs, Ex-Vessel Debris, Water Injected, Extensive CCI, WW Vent
CD-005.APET-018	0.7%	RCIC Lost on ED, FLEX Fails, Cont. Re-Isolated	SRV Opens, Ex-Vessel Debris, Water Injected, Minimal CCI, WW Vent
CD-005.APET-021	0.7%	RCIC Lost on ED, FLEX Fails, Cont. Re-Isolated	SRV Opens, Ex-Vessel Debris, Water Injected, Extensive CCI, WW Vent
CD-019.APET-017	0.7%	RCIC Fails Early, Operator ED, FLEX Late/Unavail	SRV Opens, Retained In-Vessel, No Vent
CD-019.APET-016	0.6%	RCIC Fails Early, Operator ED, FLEX Late/Unavail	SRV Opens, Retained In-Vessel, DW Vent
CD-016.APET-028	0.6%	RCIC Succeeds Early (0-6 hrs), FLEX Succeeds, No Venting, ED	SRV Opens, Ex-Vessel Debris, No Water Injected, LMT Occurs
CD-017.APET-001	0.5%	RCIC Succeeds Early (0-6 hrs), FLEX Late/Unavail	MSL Occurs, Retained In-Vessel, WW Vent

Preliminary results

SAWA to RPV Dominant Results Visualization



MAAP5 Results for Dominant Mark I Scenarios

MAAP5/WinMACCS Execution

- Execution of 12,168 individual MAAP 5.02 and WinMACCS calculations
  - 13 Core Damage endstates
  - 39 APET endstates
  - Overall 507 endstates for each filtering strategy alternative
  - 24 alternative cases
- Python used to construct individual MAAP5 inputs from CDET and APET structure
- Automated transfer from MAAP5 to WinMACCS

EPRI's new "Phoebe" HPC system

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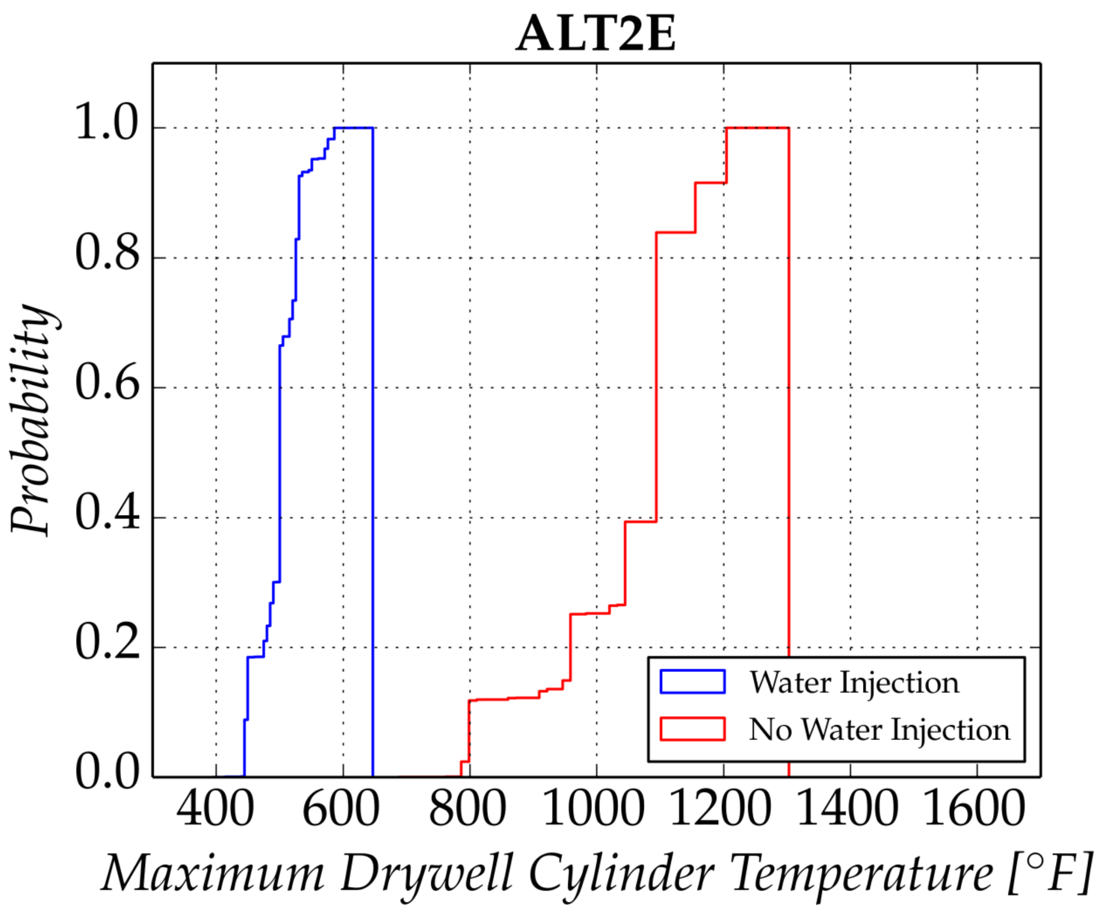
Water Addition (SAWA) Protects Containment by Reducing Drywell Temperatures



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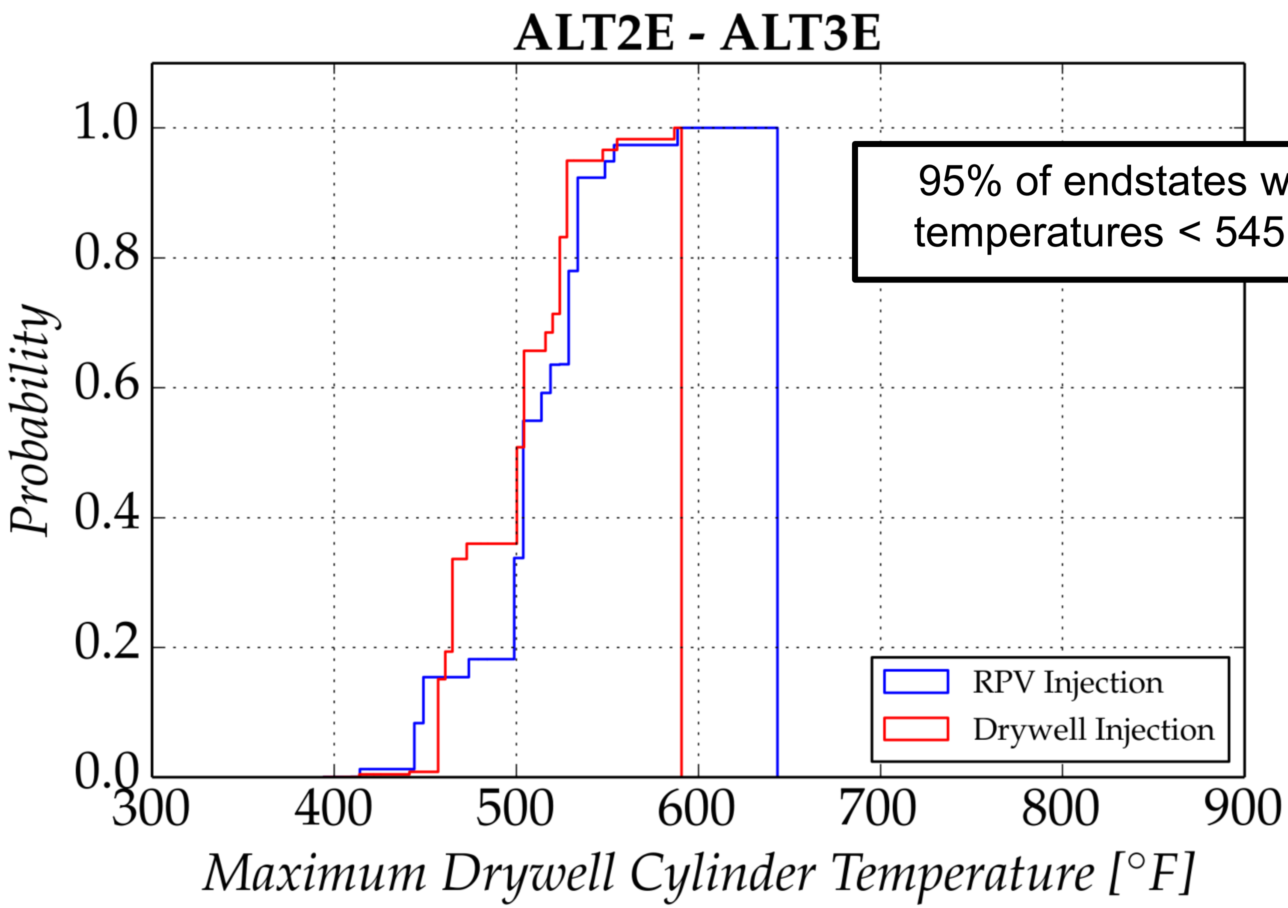
Impact of Water Addition Location on Drywell Temperatures
(assuming water addition succeeds and Drywell vent implemented)



95% of endstates with temperatures < 545 °F

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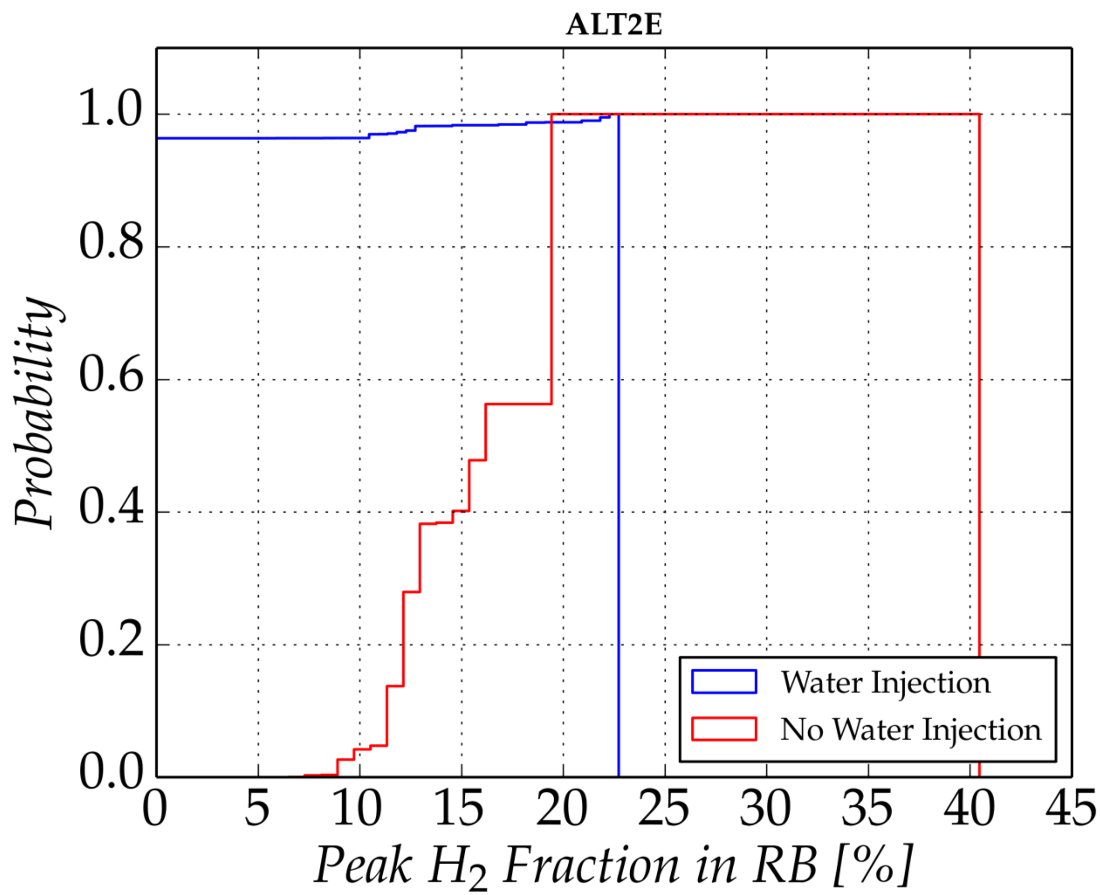
Water Addition (SAWA) Impact on Peak H_2 Concentration in RB



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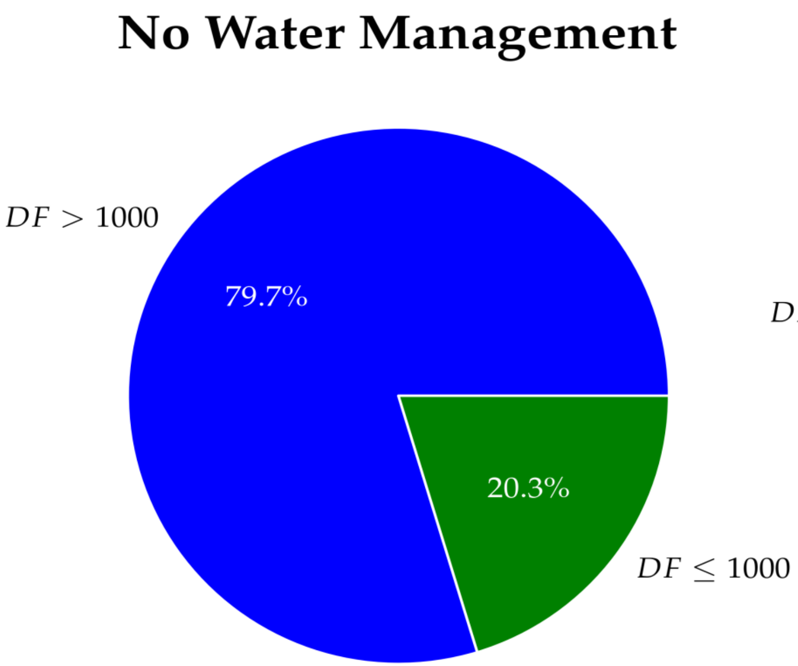
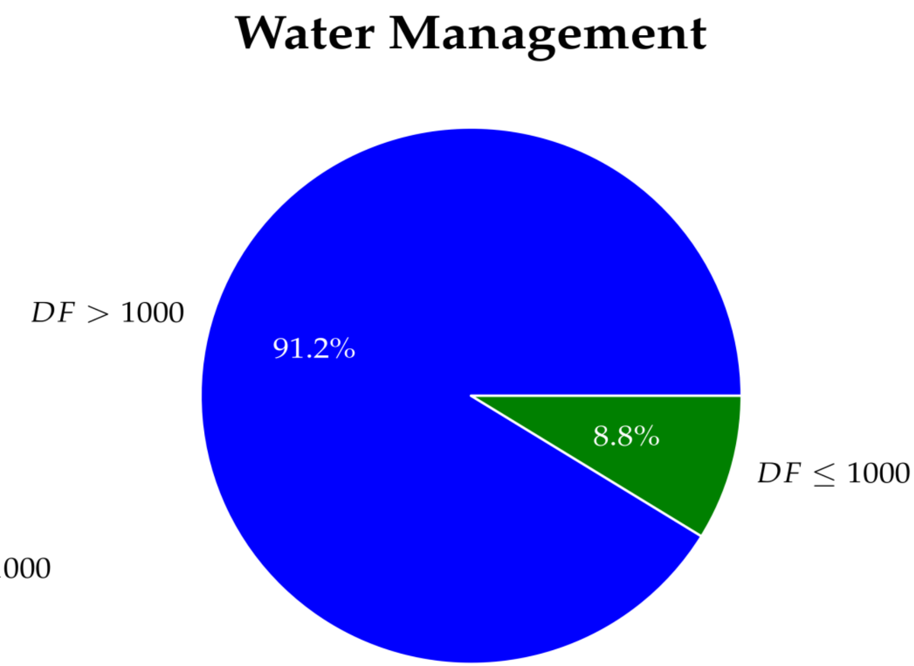
Impact on DF with Water Management (SAWM)





Preliminary

Overall DF for All Alternatives

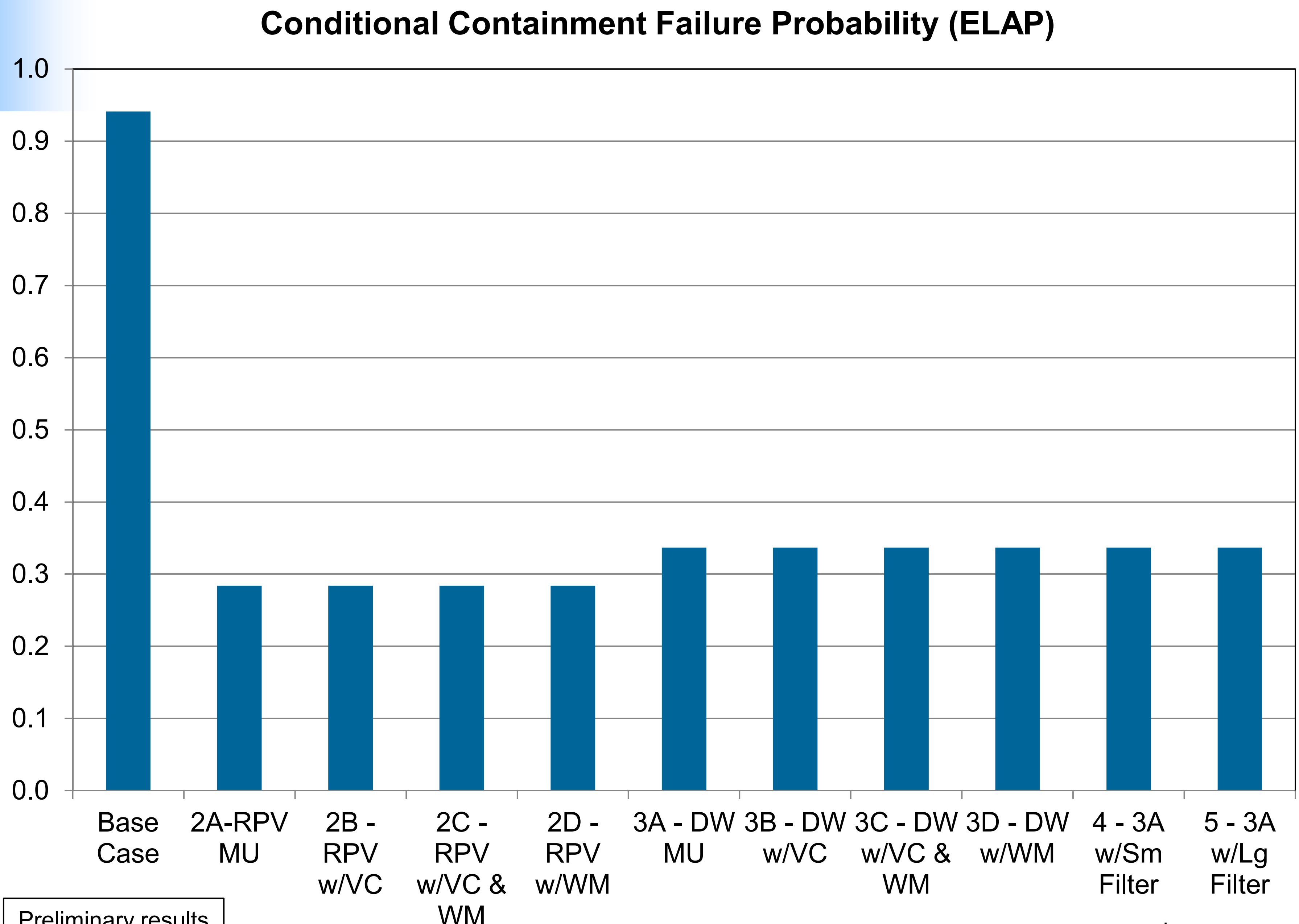
Preliminary

High-level Results for Mark I Containments

(Note Numbering Scheme for Alternatives
in these Slides is Based on a Prior Numbering Scheme)

Filtering Strategies Rulemaking Figures of Merit

- Conditional Containment Failure Probability (CCFP)
- Margin to LCF Safety Goal
- Margin to IEF Safety Goal
- Max Averted Cost
- Net Benefit



Preliminary results

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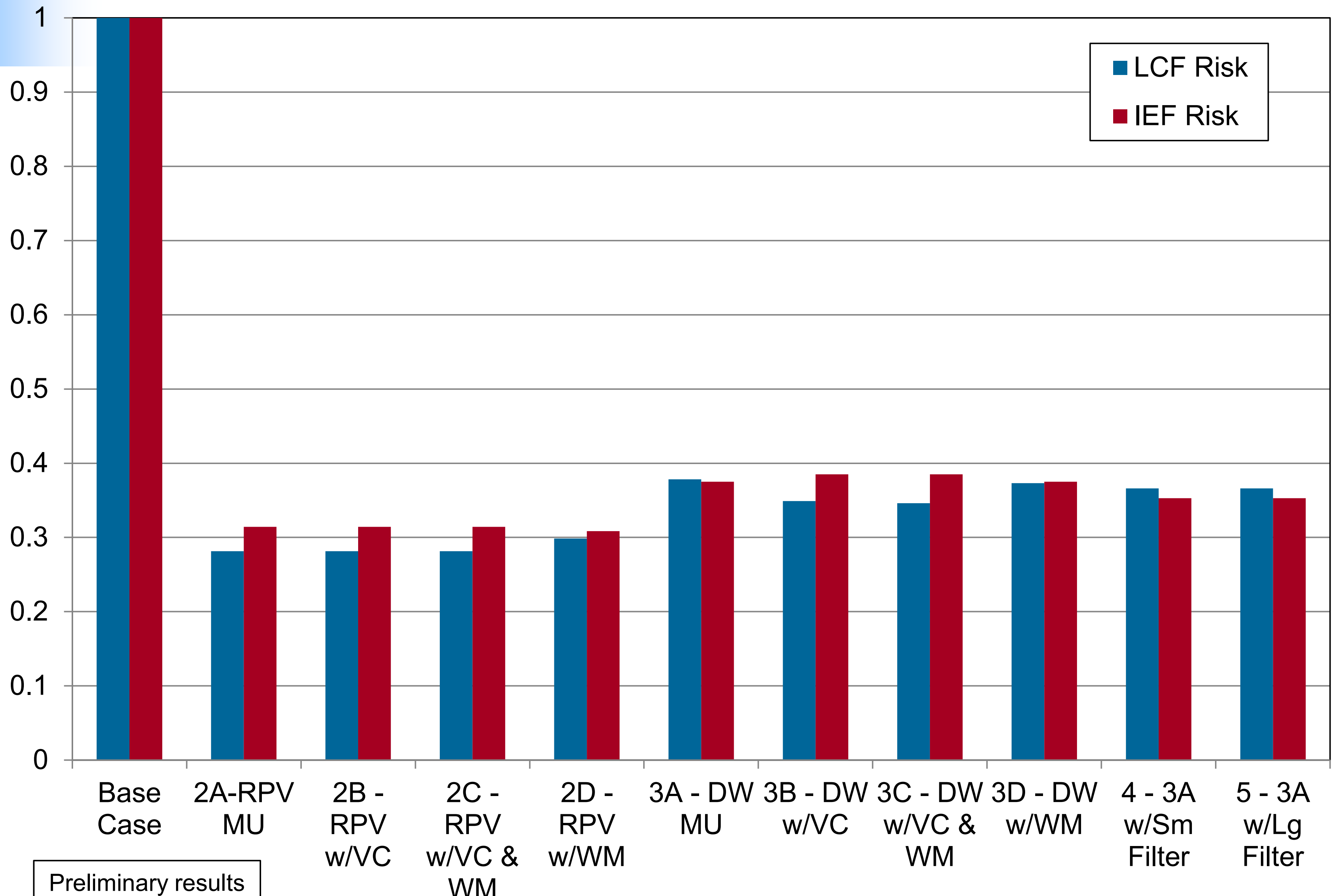
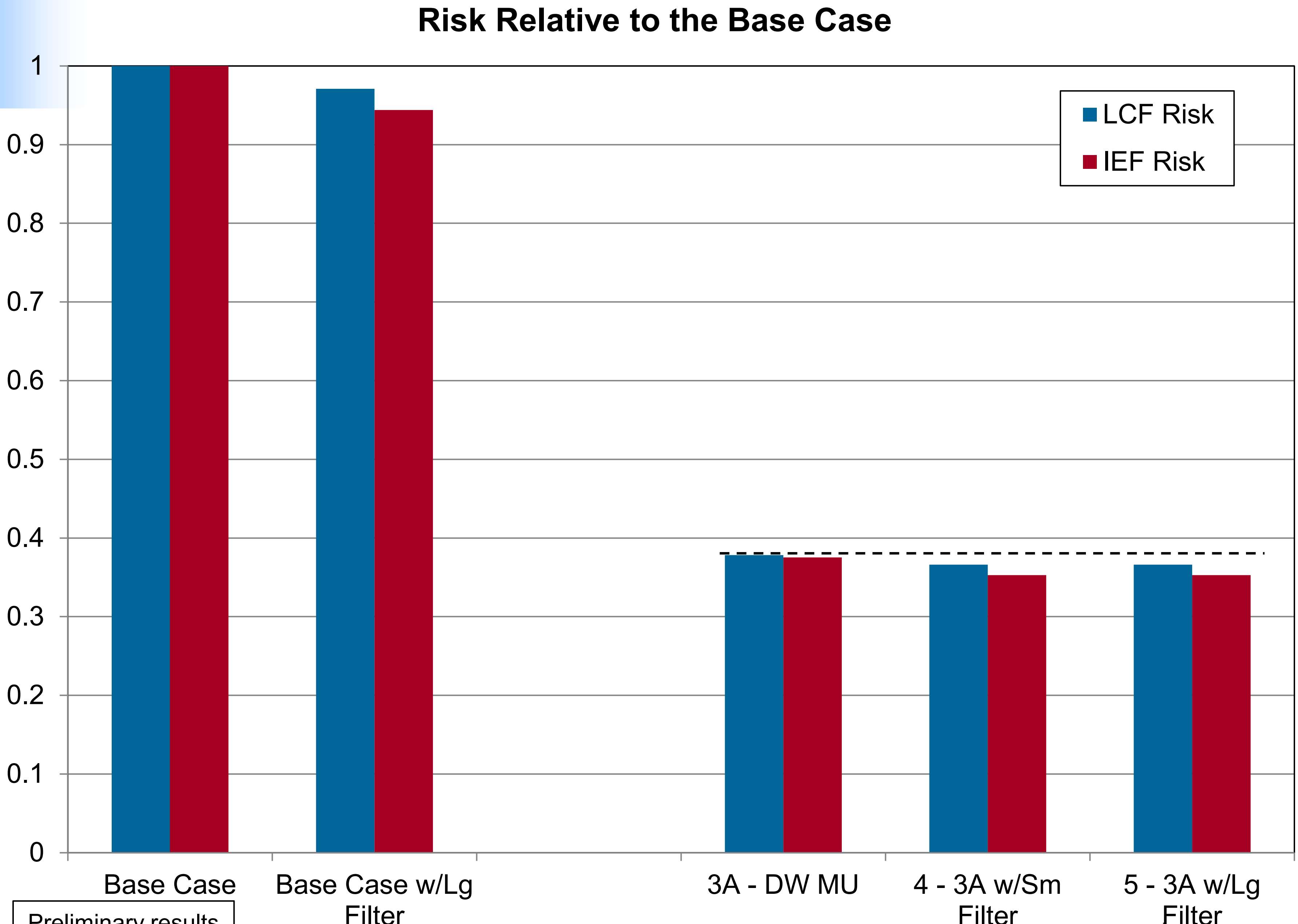
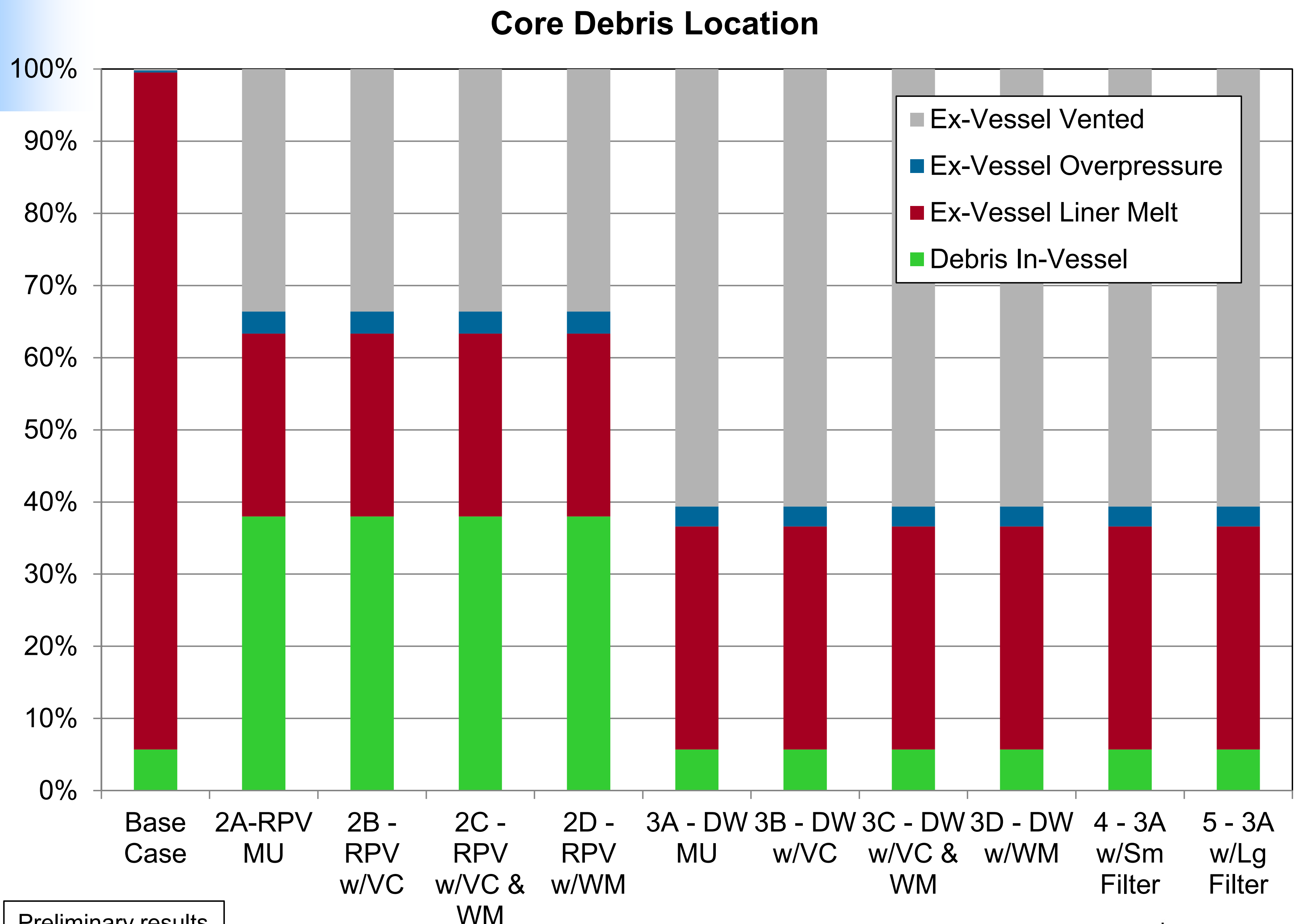
Risk Relative to the Base Case



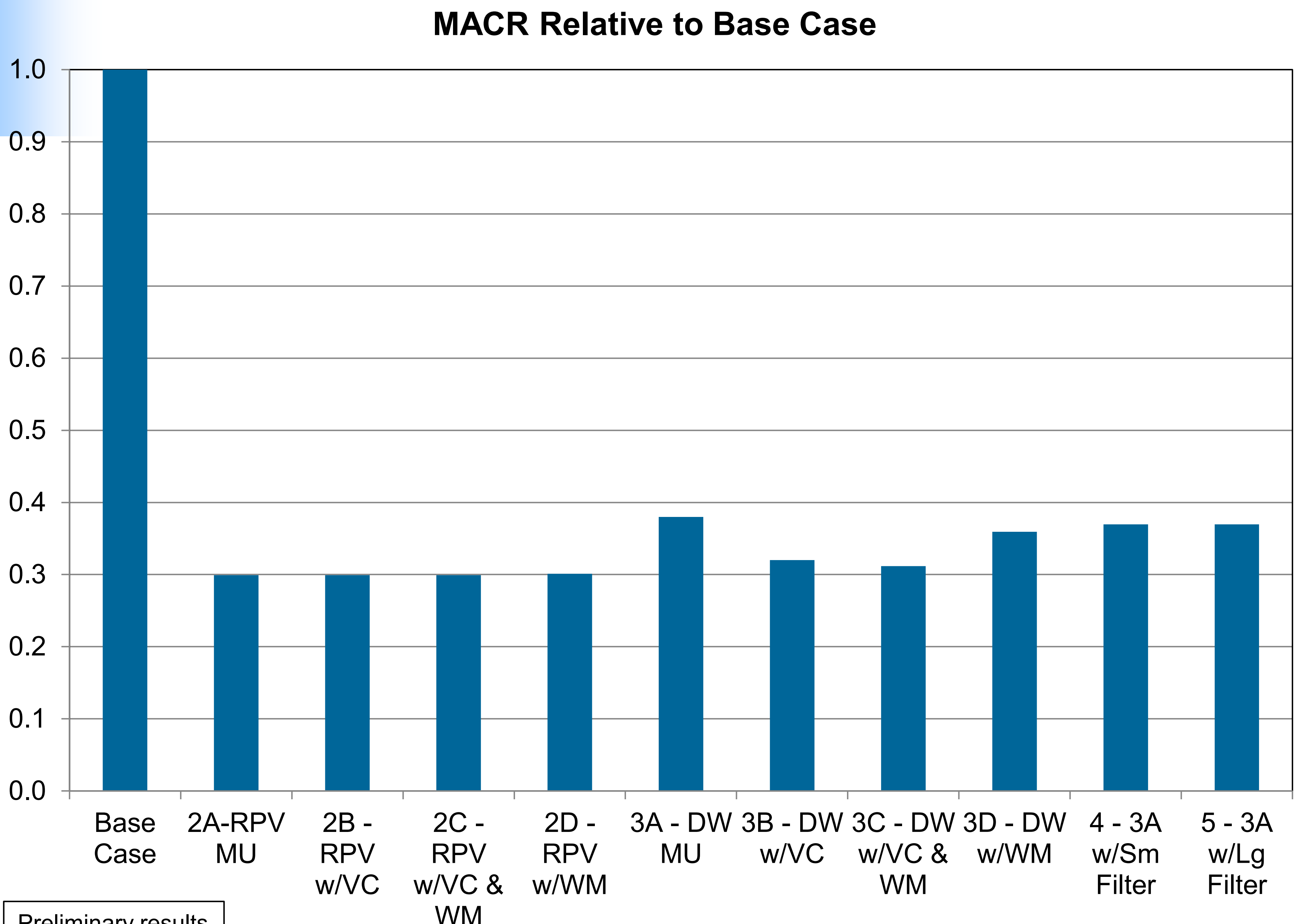
Preliminary results



Preliminary results



Preliminary results



Preliminary results

Filtering Strategies Rulemaking Sensitivities (To be completed)

Logic Model

- ✓ ELAP frequency
- ✓ FLEX equipment reliability
- ✓ Human error rates for
  - FLEX
  - Water injection
  - Effective water management
  - Vent control
- ❖ Vent control pressure band

Phenomenological

- ✓ MSL rupture/SRV seizure likelihood
- ✓ In-vessel retention likelihood
- ❖ Delay of DW shell failure
- ✓ Bypass Prevention (Mark II Only)

Benefit Related

- ✓ $/person-rem
- ✓ Discount rate

Legend

- ❖ Requires new MAAP/MACCS Runs
- ✓ Done using existing integrated risk model

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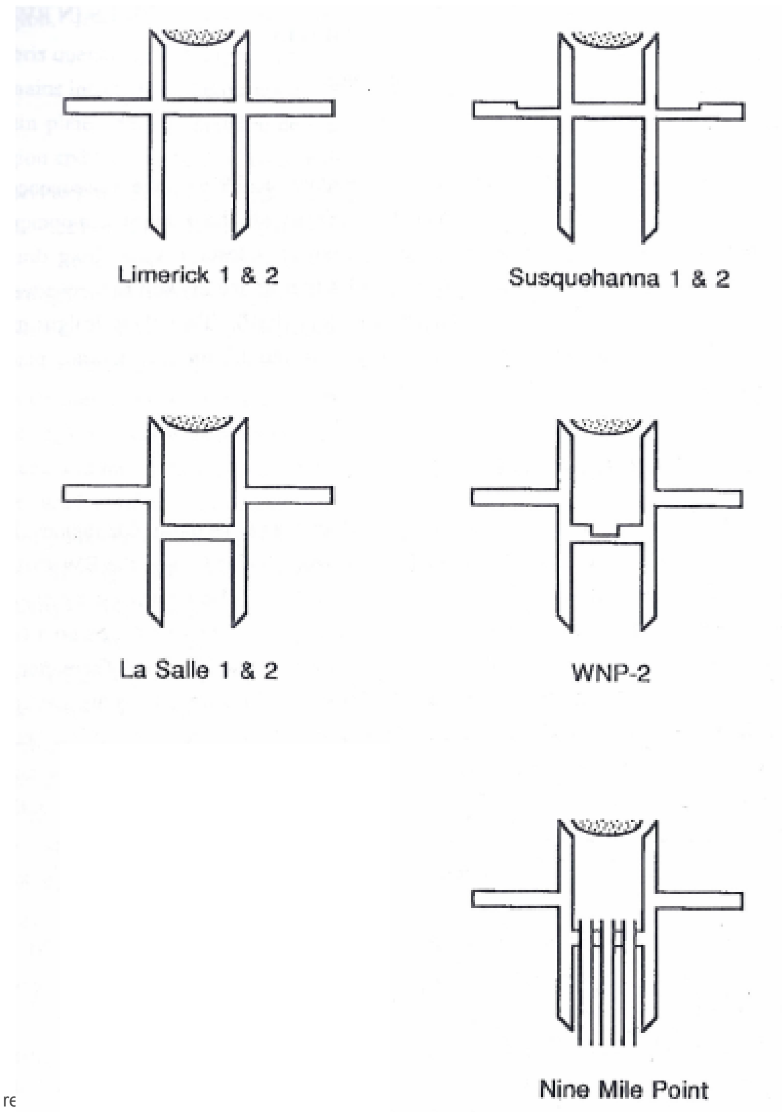
Mark II Containment Considerations

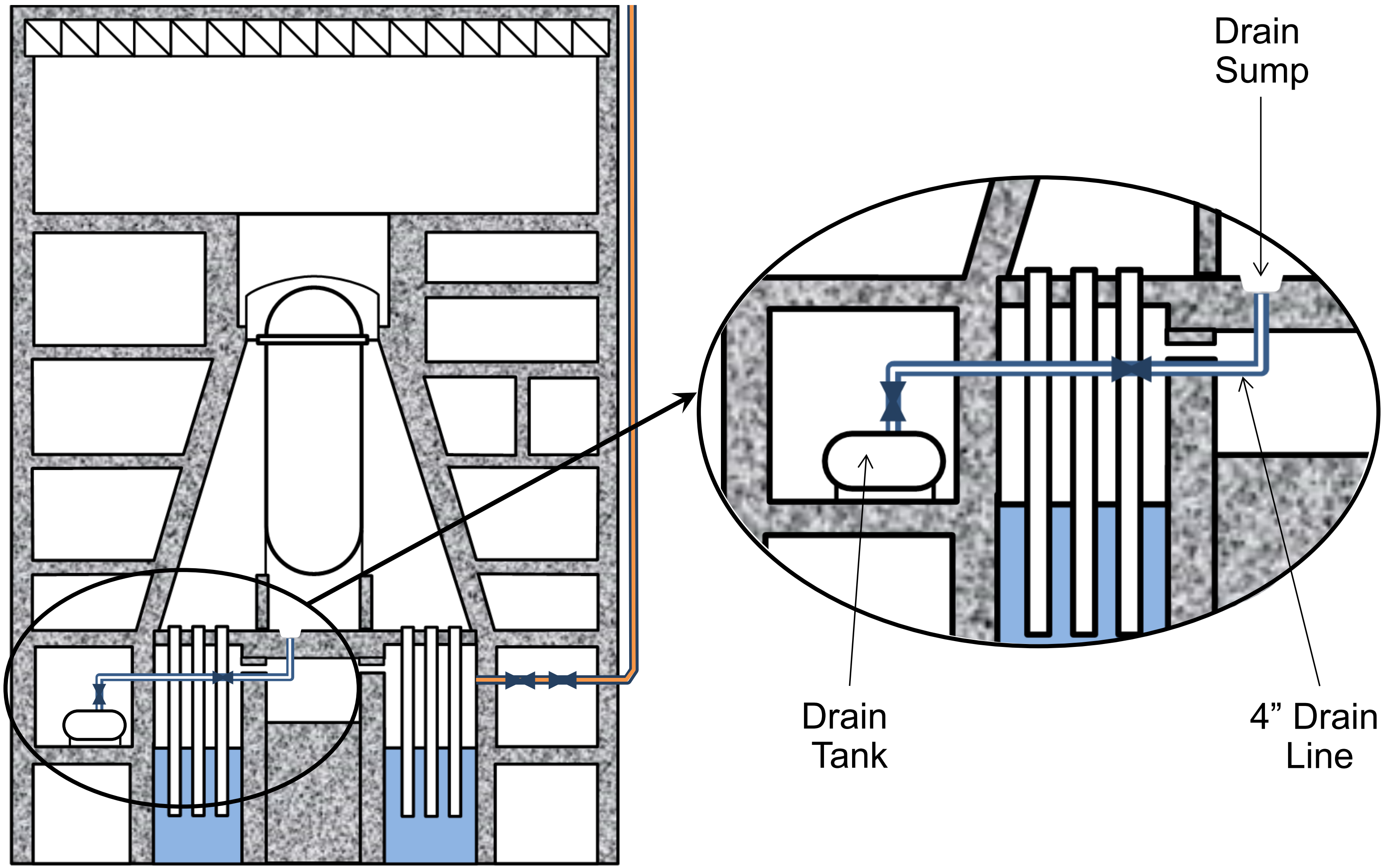
Mark II Containment Considerations

- Mark II containment designs vary considerably in their severe accident response characteristics
  - Pedestal sump drain lines
  - Sunken/Level pedestal
  - Downcomer locations
  - SP water under pedestal
- Requires multiple technical evaluations
  - Technical evaluation to build off of NUREG/CR-5623 & -5528
  - Primary focus is on understanding SP bypass mechanisms and magnitude

Mark II Cavity Design



Typical Mark II Containment – Pedestal Drain Line



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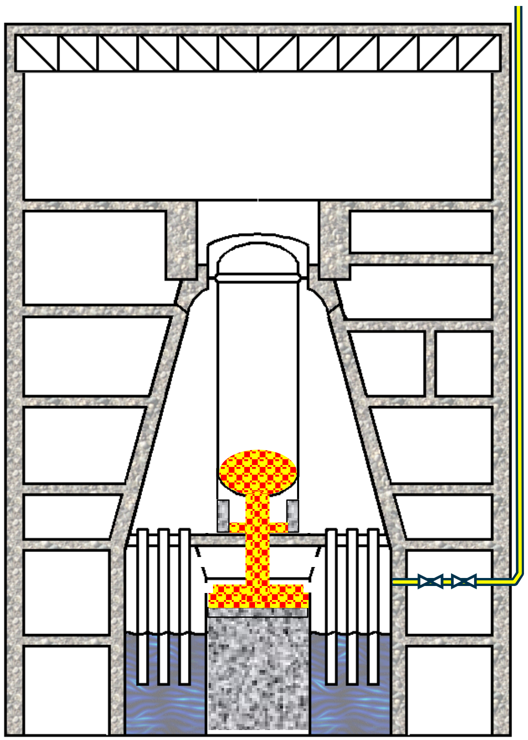
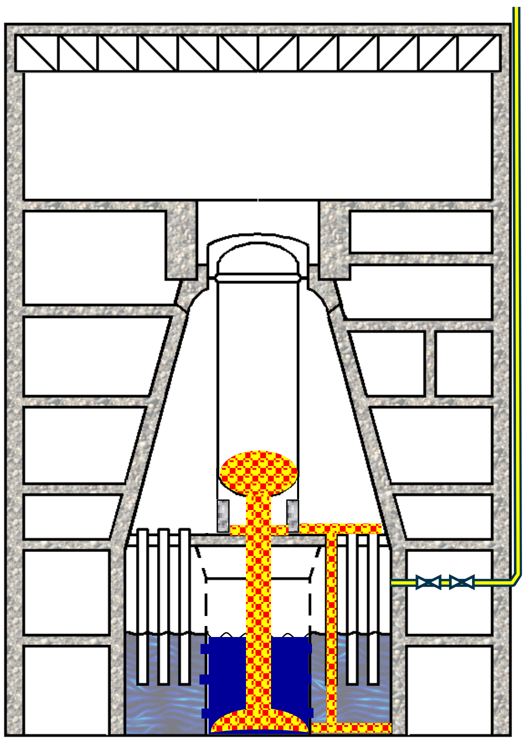
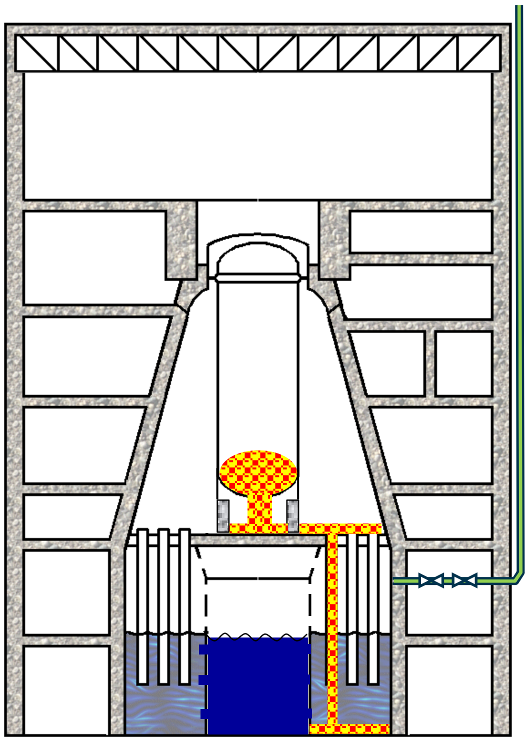
BWR Mark II Containment Configurations



- Drywell floor penetrated in pedestal by debris (via drain line melting)
- Debris falls on concrete fill below
- Suppression pool bypassed
- WW vent release not scrubbed



- Drywell floor penetrated in pedestal by debris (via drain line melting)
- Debris submerged in pool
- Suppression pool bypassed, but majority of debris is under water
- WW vent release partially scrubbed



- Drywell floor penetrated in pedestal by debris (via downcomer)
- Debris submerged
- Suppression pool <u>not</u> bypassed
- WW vent release scrubbed via pool

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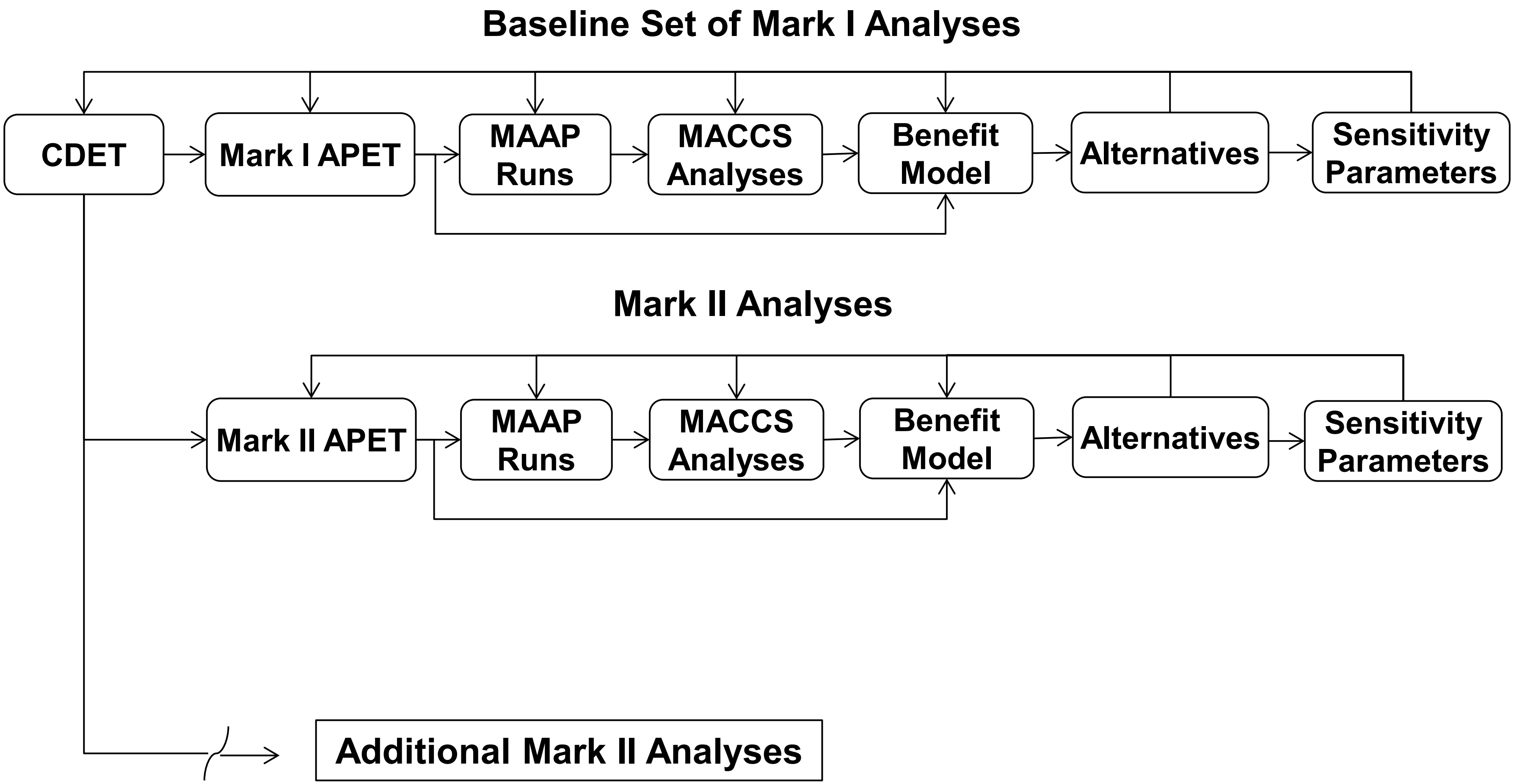
EPRI Analysis Framework



Summary

Summary and Conclusions

- Industry technical evaluation has assisted industry in recommending water addition as a preferred option under Phase 2 of EA 13-109
- Industry insights to-date indicate that for Mark I and II containments there are:
  - significant safety benefits from accident management actions, including wetwell venting and water addition,
  - marginal safety benefits from any additional filtering strategies.
- Mark II bypass issue still under investigation

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BACKUP SLIDES