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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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FUKUSHIMA SUBCOMMITTEE

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WEDNESDAY, OCTOBER 31, 2012

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ROCKVILLE, MARYLAND

The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 1:00 p.m., Stephen P. Schultz, Chairman, presiding.

SUBCOMMITTEE MEMBERS:

STEPHEN P. SCHULTZ, Chairman

J. SAM ARMIJO, Member

CHARLES H. BROWN, Member

MICHAEL L. CORRADINI, Member

JOY REMPE, Member

MICHAEL T. RYAN, Member

WILLIAM J. SHACK, Member

GORDON R. SKILLMAN, Member

JOHN W. STETKAR, Member

NRC STAFF PRESENT:

ANTONIO DIAS, Designated Federal Official

JERRY BETTLE, NRR

BOB DENNIG, NRR

BOB FRETZ, NRR/Japan Lessons Learned Project Directorate

TINA GHOSH, RES/DRA

JOHN MONNINGER, NRR/Japan Lessons Learned Project Directorate

WILLIAM RULAND, NRR

ALSO PRESENT:

JEFF GABOR, ERIN Engineering

PAUL GUNTER, Beyond Nuclear

STEVE KRAFT, NEI

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P R O C E E D I N G S

1:02 p.m.

CHAIR SCHULTZ: I'd like to call the meeting to order. This is a meeting of the Advisory Committee on Reactor Safeguards Subcommittee on Fukushima. I'm Stephen Schultz, Chairman of the Subcommittee. Members in attendance today are Dick Skillman, Sam Armijo, John Stetkar, Bill Shack, Joy Rempe, Mike Corradini. I believe Mike Ryan is going to join us, and other members may join us later in the afternoon.

The purpose of today's meeting is to receive a briefing and hold discussions with the staff and the industry on the discussion of a position paper addressing the value of filtered vents. The entire meeting will be open to public attendance. Rules for the conduct of and participation in this meeting have been published in the Federal Register as part of the notice for this meeting.

The Subcommittee will hear presentations by and hold discussions with representatives of the NRC staff and other interested persons regarding this matter. The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions, as appropriate, for deliberation by the full committee.

The staff is currently finalizing a position paper that is due to the Commission by the end of November. The full committee briefing on this same topic is scheduled for tomorrow, November 1st, starting at 10:15 a.m. Also, the ACRS will be writing a letter on this topic during this week's full committee meeting.

Antonio Dias is the Designated Federal Official for this meeting. A transcript of this meeting is being kept and will be made available, as stated in the Federal Register notice. It's requested that speakers first identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

We've received no written comments associated with this topic today. We have received requests for time to make oral statements from Mr. Paul Gunter. I understand that there are other stakeholders in the audience, as well as on the bridge line who are listening in today for these proceedings, and they will also be given the opportunity to address the Committee at the end of this briefing.

We do want to welcome both the industry and the staff. This is not the first meeting we have had on this topic. Rather, as indicated, it's one that just precedes the publication or the transmittal of the staff's report to the Commission later this month.

We'll now proceed with the meeting, and we're going to start with presentations by Steve Kraft and Jeff Gabor from NEI and ERIN Engineering respectively. And so I'll call upon you, Steve, to open the meeting. Thank you.

MR. KRAFT: Well, thank you, Mr. Chairman. Pleased to be here. Thank you, Subcommittee, for the invitation. Thanks to Antonio for organizing our attendance. I am Steven Kraft. I am Senior Director, Fukushima coordination and strategy at NEI. I am pleased to have Dr. Jeff Gabor with me from ERIN Engineering. Rick Wachowiak from EPRI was going to join us but travel and whatnot and I understand he has a personal issue at home, so he's unable to be here. And I don't believe he'll be on the phone either.

MR. DIAS: I provided him with the phone at the --

MR. KRAFT: Yes. I'll tell you later. It's a personal matter, I think, this afternoon. So before we move on and go through our slides, go through our discussion here, I just wanted to disabuse anyone in the room who thinks that somehow the nuclear industry is all-powerful. I attempted to get the Metro shut down for one more day so we could avoid the meeting. Alas, I was unable to do so, so here we are.

As you know, we have been working on this question of filtering strategies for some time. There have been numerous interactions with the staff, many in this room, all in public. I appreciate the staff's time with us, understanding their work they've done, they're wanting to understand the work we've done. And the discussion we're going to have with you in the short time we have available will be based on our October 5 letter that I believe has been circulated, as well as what we're doing beyond that letter. There are some other activities that we're engaging in.

I just want to, at the very top of the discussion, state the industry position so there is no question that you don't think, as we walk through some of the further discussion, that somehow we think that filtering and preventing land contamination is not a good idea. Of course we think it's a great idea. It's something that we learned from following the Fukushima event, and you see right here in three bullets the position that is stated in the October 5th letter. We've explained it to the NRC Fukushima steering committee. We've briefed commissioners on this. MARK I and MARK II containment should have the capability to use a variety of containment filtering strategies. This is not limited to MARK Is and MARK IIs. We know this goes beyond at some point, but this is what's before the Commission at the moment because of the way the reliable hardened vent order worked. This should be a performance-based strategy requirement, in our view, founded on scientifically factual analyses and a comprehensive approach that ensures containment. I cannot stress more strongly our view that keeping the radionuclides in containment ought to be the goal, and that's kind of where we start our discussion of filtering strategies.

Now, having said that, let me drop back and let me discuss with you the context with which we look at this. The reason this context is so important is the very first bullet: beyond design basis events. The way we look at beyond design basis events, the way this agency appears to be approaching beyond design basis events is different in many respects than design basis events. As we worked our way through application of the three orders that we're now implementing, as working our way through seismic and the flooding, walk-downs, evaluations, things like that, the approach is different; and it's because we don't know where the line is. We all know what design basis is. It could change in the future. We may have to make adjustments, but that's different than beyond design basis.

Secondly, there's an extremely low chance of ever needing filtering. I don't think it's news to anyone that the goal is to prevent the accident in the first place. And by the way we have added additional enhancements to what everyone knows we call the B.5.b capability as a result of the terrorist attacks back in '01, we've now expanded that into what we call FLEX. In fact, this last event, Sandy, coming through unexpectedly, unprecedentedly, we exercised the system. When Oyster Creek lost offsite power and one of its diesels kicked on, they immediately called INPO. INPO immediately walked down, INPO had their ERC staff, immediately walked down the list to find who had a backup portable generator of the right size, etcetera, that could be moved immediately to that plant. They identified three or four different places that had one. The nearest one was Susquehanna Station, I believe, PP&L. They were preparing to mobilize and move that generator when they got the call to stand down. So that wasn't without, you know, going after a way to create this drill. We had a drill, and it worked extremely well. And all that goes to this point of preventing the accident.

Now, granted, I don't think we're anywhere near close having an event at Oyster Creek. It was just an opportunity because they were offline, they had the rising water, they lost offsite power, you know, things like that.

Reliable hardened vents provide a heat removal path while filtering and filtering strategies, whichever way you want to do it, has to do with reducing the impact of potential containment releases. One is not the other, and that's an important point. I sometimes hear confusion in that discussion that begins substituting one for the other. Again, all this goes to the way you think about what's an appropriate requirement in a beyond design basis event when you have core damage and you have to consider preventing or mitigating releases coming from containment. And I don't think there's any secret that previous NRC evaluations on containment filters, they've never made the grade. Every time they've done an analysis, they've said it doesn't make the grade. They've sat in this room and briefed you on October 3rd. You know, again, no surprise there.

That leads me to the last bit of context is the use of qualitative factors in extreme scenarios. There's absolutely nothing wrong with using qualitative factors. There are certain things where it's only appropriate: EP, emergency planning; security, really not amenable to traditional risk and cost benefit analyses, so you use qualitative factors.

In the case of the filtering analysis, what NRC staff said was, well, we can't make it to justify a filter, so we're going to go on to qualitative factors, and that's perfectly okay, provided, of course, the Commission makes that decision, and I think that's what the staff is aiming at. But the point being, again, when you're at a point where you have to go all the way through these analyses and get to qualitative factors to make a determination, I think that gives you cause to think what is it you're really trying to accomplish here and what's the best way of going about doing it? And extreme scenarios fits in that same way.

And the reason I put that up there, and I'm not trying to suggest something is not right in the way these analyses are being done, but I have met with a lot of people, have met with a lot of vendors, have sat down and met in our meetings with NRC, even our own industry. There's some cherry picking of scenarios going on. So, for example, if you want to posit that during the event and you're flooding up containment and you have to switch over in the scenario that Jeff and his colleagues devised where you switch over from the wet well vent to the dry well vent and, all of a sudden, quote, all hell breaks loose, gee, and your scenario ain't going to work, well, that can't be limited to just my scenario. If all hell breaks loose and takes down my spray header, what makes you think the filter survives? Think about what you're designing these things to. So I just think the point that -- and, again, it's a matter of not purposely picking scenarios that make the case one way or another, and I think the EPRI report, and Jeff can talk about it if need be, is very comprehensive, particularly in the sensitivity analysis.

And going to this point of keeping and having the accident is that we continue to take actions and adding activities and FLEX and everything else to ensure a very low frequency of release. There is in the backup slides an event tree that was prepared by Jeff and his colleagues that make this point about how much you have to go through, how much has to break, how much has to go wrong until you get to releases. I won't bother to read this list. You all know better than I do. We'll note on the bottom, just to emphasize what I said before with the NRC analysis, using the traditional regulatory analysis did not justify filters and never has. Again, that's why I put our position up first. I'm not saying that to avoid filtering. I'm saying it to give you context as to where we are in making this decision.

So the EPRI work, which was presented to you by Rick and Jeff a month or so ago, these are the insights that we got out of the EPRI report but also, as we paid attention to the NRC evaluations, are the same insights. First is all filtering strategies with or without external filters. Whether you stick a filter on the end of the vent pipe or not, you must rely on operator actions to cool the core debris to be effective. Let me repeat that: rely on, first, operator actions. Operator actions are not unique to filtering strategies. And, secondly, cool the core debris to be effective. If you look at the event tree, any scenario where you fail to cool the core debris results in a release, regardless of whether you have a filter or a filtering strategy in play. So the goal is to always cool the core debris. Prevent the accident in the first place and cool the core debris.

We'll make that point in the next slide.

Filtering strategies and external filters require the same conditions to be effective. That's the whole point of that event tree. Active core debris cooling. We added the idea of containment vent cycling, which is in the EPRI report. You want to keep the torus or the suppression pool as long as possible below saturation, so you maintain the filtering capability. You have to inject water in containment to filter potential releases through water spray and flooding. They also filter the airborne aerosol. You cycle the vent. It also manages -- let me just mention hydro before someone else does. Hydrogen has not been explored. The NRC made hydrogen control a Tier 3 issue, so I don't think that they're there yet. But we've talked about it a little bit. The EPRI report points to the possibility of the vent cycling as part of a strategy. It can help manage hydrogen. It may not be the complete answer, and it's something that needs to be worked on. I'll just say that right now.

And then, of course, we think you can get an achieved decontamination factor over the event of 1,000 DF, and that seems to be a common international requirement.

MEMBER SKILLMAN: Steve, before you go on, on your first bullet, the comment "filtering strategies and external filters require same conditions to be effective," could you explain that a little more, please?

MR. KRAFT: If you're not cooling the core debris, it doesn't matter if you have a filter at the end of the pipe or not. You have to cool the core debris in order to prevent releases that will bypass the vent, either going through the liner, a seal failure, various things like that. That water on the core debris also gives you the filtering that our filtering strategies take advantage of. So you got to get the water in to cool the core debris no matter what, and then you can take credit for the water in containment to provide filtering. That's what that concept is.

But remember what I said earlier in our basic position is that it's a performance-based approach in the way we see it, which means if some plant has a unique situation or wants to do, for whatever reason, their own analysis, they want to take an action and put in a filter, put in a filter. The EPRI report makes a conclusion, which is extremely important, that small specific DF filters may be useful to help give you that additional DF if you need to do it for whatever reason. And we can get into this question as to whether that's the same water-based filter or not. We think it's not. We think it's going to be something else because of the aerosol size issue that was discussed by Jeff and Rick when they were here.

MEMBER SHACK: Just on the containment vent cycle, will the containment hardened vent that you're going to put in in response to the current order do you think be sufficient to use the containment vent cycling strategy?

MR. KRAFT: The answer is we don't know, but we are going to be engaging in, and the last slide I have here will discuss this, a pilot tabletop project. We actually began discussing that this afternoon on the phone, planning for it, where we want to look at the practicalities of how you implement these strategies and how do you make a plant look like the analysis. I don't think plants look like the analysis yet. I don't think all the plants have the capability to inject the water. They certainly don't have both the dry well and the wet well vent. SAMGs have to be updated. I'll cover that a little bit later.

But, yes, your point is that's how you do that. And the answer is it would have to. Can it do it now the way it's being designed? I wouldn't think so, but I don't know all the different . . .

DR. GABOR: Yes, I think, you know, the two, obviously there's an automated valve that could provide that benefit also through operator action. I mean, even if you look at some of the plant-specific technical support guidelines and you look in the details of their current strategies on containment venting, you might see discussion in there, depending on the plant, about re-closing the vent and trying to control the pressure within a band.

MEMBER SHACK: No. I mean, the staff makes a distinction between a severe-accident-capable vent and an vent that essentially gets rid of decay heat before you have core damage. Now, EPRI doesn't seem to be drawing that distinction.

DR. GABOR: Clearly, in our strategy --

MEMBER SHACK: To be accident capable?

DR. GABOR: Yes, yes, because in our strategies you're going to be venting fission products, radionuclides, hydrogen. So that is part, you know, a severe accident type event is implicit in our strategy.

MR. KRAFT: And it's hard to imagine NRC wanting to require a filter without also requiring that vent. I mean, they go hand in hand. It's not an option.

MEMBER CORRADINI: But maybe just to clarify, so the difference in character of the event that would have severe-accident-capability is what? Not the filter part but --

DR. GABOR: I think it's issues around shielding and accessibility.

MR. KRAFT: The ability to operate it with a melted core present, things like that. And I think utilities are looking, you know, they know that water stops short of core damage, but I think a lot of them are looking forward saying, okay, if I have to make a change to it, what do I have to do? Shielded operating stations, retrods, you know, things along those lines. When you look at the photos that NRC has shown of the European plants, you see lots of retrods. I don't like retrods myself, but that's another matter. But they, you know, some kind of remotability.

MEMBER ARMIJO: Absent the issue of shielding, are there any BWRs today that have the capabilities of the --

DR. GABOR: I think there are manual-operated valve capabilities in some of the existing plants.

MEMBER ARMIJO: But if they had the shielding and it's --

MR. KRAFT: Well, one thing we learned from the post Fukushima reviews is some of those valve locations require you to --

MEMBER STETKAR: It might take some ladders and ropes.

MR. KRAFT: -- require you to be an acrobat to get to, so that's part of the change on reliable. So the answer is yes. The question is how you actually execute it. That's another question.

CHAIR SCHULTZ: But I do hear that, although there may be a comparable understanding of the hardened vent versus the severe-accident-capable vent, that there is a thought process ongoing that the industry feels one ought to move in the direction of a severe-accident-capable vent. However, it still sounds as if the full push isn't there to achieve that by all utility owners.

MR. KRAFT: Okay. I'll come back to the one before, but, since we're talking about this, the tabletop calculation exercise we want to do, it will be in, basically, three phases. The first phase, which is a feasibility phase, is to investigate, it says here, the practicalities of how you make this work. Containment vent filter consideration is one of the bullets, obviously. We need to figure out how you actually operationalize what it is EPRI came up with in the analysis. So we need to figure out, sitting with plant people, using a specific plant, you know, with their operating staff involved, saying, okay, how would you do this or what changes would you need to make to do this. We need to figure this out. We hope to have that done sometime in January, the first phase.

MEMBER STETKAR: Have you talked to any of the European boiler owners? I know of one plant in Switzerland, for example, who has a filtered vent, SAMGs in place. Have you looked at how they actually implemented? Have you talked with them?

MR. KRAFT: No, but we rely on the BWR owners to have that information.

DR. GABOR: I mean, if it's the one I'm thinking about, they made a presentation at the RIC, and they went into some detail about their design, which, by the way, did include debris cooling capability, all of that. And I remember there were some questions that came up about did they factor in in their design of their external filtering, did they factor in any containment filtering going on or changes to aerosols or any of that. And the answer we got back was, no, they hadn't, that they really didn't take, I mean, they knew they had to have the debris cooling, but that wasn't really part of the specs on what they wanted to filter.

MEMBER STETKAR: I was thinking more in terms of, you know, the first bullets look at integration of the design, operational considerations, and that type of exercise.

DR. GABOR: I think to a large extent, what we're going to find is a lot of these strategies are too far astray from what the current, at least in the boiler, what the current SAMGs would indicate. There might be, like Steve points out, there might be some design changes or some procedure enhancements, but, you know, the basic functions of venting and flooding containment and spraying containment already exists there.

MEMBER STETKAR: That's the reason I asked about the Swiss because they've implemented extensively SAMGs. I actually haven't looked at them.

It's not my area of expertise. But I know they have them, and they've walked through them pretty carefully or extensively walked through them pretty carefully. So I was curious whether you talked to them to see how far astray they go from the U.S. SAMGs, in a sense.

MEMBER ARMIJO: Could I go back to your second slide, Steve?

MR. KRAFT: Sure.

MEMBER ARMIJO: You made the point that the industry approach is really emphasizing that you should ensure containment. But one of the arguments in favor of the filters is it reduces the reluctance of operators to vent earlier. They have the filters there and, rather than threaten the containment in any way, to vent them at lower pressures or something. And is that counter to the industry philosophy that, hey, we're going to contain as long as we can and we'll vent only at very high --

MR. KRAFT: No, we didn't say contain as long as we can. We said contain the radionuclides in containment, which may require early venting in order to control pressures and temperatures in the suppression pool.

MEMBER ARMIJO: Okay. So there's no objection to earlier --

MR. KRAFT: Absolutely not. The contain is contained radionuclides in containment. One of the things that's not been lost on utilities where we do look at, when they have looked at what it would take to put a vent filter, external filter is it's outside containment, it's in a shielded building. It's another hazard in the yard you have to worry about when you're approaching the damaged plant, etcetera, etcetera. The biggest question I get asked by the utility CNOs is can you get me one small enough I can keep in containment? And so that's when you look at the small, the specific DF built-ins that are not water-based, because you're using the water to strip out the larger aerosols, you see some designs that look like high-grade, you know, steel wool sort of thing and progressively finer mesh. There's other designs around. That part of the filter, if you look at the water filters, as I understand the designs, you'd have the sparger and the water at the bottom of the tank, and at the top you've got some sort of metallic device of some kind. Something like that could be done in smaller spaces. And because it's not a water tank, it could be split up in pieces and put in different compartments and pipes so you don't have to get it outside. Keeping it in containment seems to be a very important matter to our utilities, so that's what we meant by containment, not that you don't open the vent.

So if I could just go to the slide I skipped. Okay. So as I discussed with Dr. Shack, the goal here is you have to figure out how to make the plant look like the analysis. Each plant would do its own analysis. There's a lot of uniqueness in plants. In fact, in the tabletop discussions, just kind of looking around the fleet of BWRs, we could choose. Of course, initially, we'd stay away from the twos because there's only six of them, although you have to look at them eventually. And then in the ones, two of them have isocondensors and the rest of don't. So you have to sort of pick something that's representative. You'll have a number of different fleets involved in the discussions. We'll have the BWR Owners Group looking at it with us. But at the end of the day, you're going to have to do this performance-based analysis.

And then we imagine at this point, having looked at what EPRI has done, here's a list of the plant modifications that need to be made. Wet well and dry well vents require it. You know, the order doesn't say wet well or dry well. It's sort of up to you. Well, if you want to make the plant look like the analysis, you need both and you need some kind of valving arrangement or some kind of auto-actuating valves or something or control circuit or something to make that work, which, of course, would have to be reliable, proven to be reliable. We'd have to include FLEX. For example, if you look at the EPRI report, it talks a 500-gallon per minute minimum pump capability. Now, that's not going to run your spray header like the 5,000 or 10,000 spray pumps. It's going to dribble it. But it's the way you get water in containment.

But FLEX now calls for a 300-gallon per minute pump. So one of the things we need to do in the pilot plant is come up with a list of things, okay, wait a minute, I need to get something else.

And then one thing I want to mention in Mark IIs, and Jeff could talk about this at great length because he's the one who taught me all about it, is that you have the capability to bypass the wet well in Mark II through a drain line and maybe other mechanisms that have to be cut off during the accident, and that needs to be worked out. There is one plant, a Mark II plant, that, for other reasons, did that, so there's precedent for that. And then, again, I'll say possible additional specific plants maybe putting a filter in, but the kind of filter I think more research is needed.

And then just to point out that we've been talking to vendors. We are encouraging the renovation. They're looking at this question. And something that I said at one of the technical exchanges, and I won't repeat who this vendor is because it's unfair, but over dinner with one of the vendors, a fellow was making the point we put in 60 filters successfully around the world. Well, sure you have. What did the design spec ask for? Filters. Did anyone ever ask you the question how do I approach this, keeping radionuclides in containment, taking advantage of the water? Inherently, I have to put in containment control. Every vendor has said we've never been asked that question.

So when they've been asked that question and they put all their smart engineers on it, they're actually coming up with first results similarly to EPRI's results and, secondly, some innovative approaches to how you would come up with a smaller, perhaps -- I say dry. Dry is a misnomer. It's dry in a sense that it's not a water media filter, but it gets wet when you use it. Dry doesn't exactly work there, but you know what I mean. It's not a water --

MEMBER STETKAR: It's not a tank of water --

MR. KRAFT: Thank you very much, Dr. Stetkar. That's right. So that's what I wanted to cover in my slides. I'm not going to go through all the technical stuff in the back. You've seen it before, but Jeff is here to answer those kinds of questions if you want to talk some more.

MEMBER ARMIJO: Yes, I had a question on the containment spray. In the analysis by the staff, I think Marty Stutzke's analysis showed that the weak link as far as land contamination or dose seems to be when you're in a situation where you can't vent through the suppression pool and you don't have enough flow to cold ignite the nozzles and have a containment do the job. Has the industry, has it looked at means of improving the containment spray system, you know, bigger pumps or better nozzles or something to ensure that it would be more effective than it's currently given credit for? It seems like that's -- the staff pinpointed a problem --

MR. KRAFT: Let me answer the question, answer two ways.

MEMBER ARMIJO: Okay.

MR. KRAFT: First, the pilot project will identify if there's a need to do that and how we might do that. That's one of the things that we'll look at for sure. But, secondly, as I understand the scenarios, and I'll ask Jeff to comment in a second, we're not relying on the spray to achieve that carefully designed spray pattern to scrub the atmosphere. The ring header is there to put water in containment, and it's the water in containment that does the stripping. The question that has come up is, once you get to the point where the wet well vent, you know, has been flooded out and you've got a core to the dry well, if you can't, how long can you wait before you have to open up that valve? In other words, are you re-volatilizing the plated out? And the answer, Jeff, is quite a few days.

DR. GABOR: Yes. So in the EPRI analysis, we looked at a lot of different sensitivities to degrading the effectiveness of the spray. We changed, you know, parameters associated with how effective you can sweep out the atmosphere. We changed droplet sizes. And we found about, I think about a factor of two benefit out of sprays versus just flooding. As Steve says, the primary benefit is getting water on the debris because that controls temperature in containment. It prevents any failures, additional sneak paths or leak paths out of containment that would bypass a filter, could bypass a suppression pool. So, clearly, the fact that you're putting water in is where we get the most bang for the buck. And like I said, about a factor of two we see by the sprays themself.

We know there's variation in the spray nozzles that people have. I think at our last meeting Dana Powers mentioned that he thought there were two primary types of nozzles that were used, some that would provide a spray coverage at low flow and some that would not.

So we haven't surveyed the industry yet. We'll have to figure that out when we do our pilot. But I think it is a good point we want to make sure we understand what the capability is. But, again, the primary benefit was in just getting the water on the floor.

MR. KRAFT: Yes. I think, though, if you look at existing designs, you probably have to achieve a 5,000 or 10,000 gpm flow to make that spray work the way it's intended, and I don't know anyone that's getting those kind of FLEX points.

MEMBER ARMIJO: I don't know what it takes to get a pump to do that, but it's probably a pretty expensive thing or, you know --

DR. GABOR: The one thing I was going to say, though, when you mentioned this scenario, and maybe I misinterpret it, you were talking about a case I thought where the wet well venting didn't work or didn't properly function, and then we had to go to a dry well. I know that scenario was presented by the staff at your last meeting, and I think there was some discussion. I had to leave early, and I think Rick said the next day that he had some dialogue with the staff on it. But we have to be sure. I mean, we can always hypothesize different types of failures. But by going to a dry well vent initially violates the procedures that we have. They're very clear that you start with the wet well vent, you maintain that vent path until you have a water level. It's very clear. In that scenario, where it does tend to show a higher release and potentially more benefit from an external filter, it is important to realize where it fits into the procedures and the strategies.

MEMBER ARMIJO: That's an event that would not happen if you followed the industry procedures.

DR. GABOR: And, again, from a probabilistic point of view, you could say that maybe there's a probability that that valve failed but the other one didn't and they would go there. There is a likelihood, of course.

MR. KRAFT: The other way to look at it, and, again, I won't mention the vendor, but one vendor approached us with the concept that you forget wet well venting altogether. Just eliminate it and forget it. Flood containment, flood-up, only have a dry well vent. When the piston effect occur, you open up the vent and you have a filter. You just have that one filter. Well, that completely violates the industry's desire to keep all the radionuclides in containment. There, the only way you have filtering is outside containment and that doesn't make any sense to anyone that I've asked about it, but it is one of the concepts that we've heard about.

MEMBER ARMIJO: Okay. Thank you.

CHAIR SCHULTZ: Could we go to the -- the next slide is the pilot study associated with that. It's described as a tabletop --

MR. KRAFT: Right.

CHAIR SCHULTZ: -- pilot. And is the investigation on one particular design or several? What I'm concerned about is a sequence of pilot studies that examines this plant and that plant and so forth, and we get into a mode where the information that we're gathering and learning and evaluating is not shared through the industry and --

MR. KRAFT: Right. I --

CHAIR SCHULTZ: -- we're spinning our wheels and taking a long time to get --

MR. KRAFT: Excellent point. We had precisely that conversation about an hour ago. To do a pilot plant pilot, you have to have a plant. So there will be a plant volunteer. Not free to say who it is just yet. That plant will be a BWR. Whether it's a one or a two, don't know yet. I'm arguing for one, greater portability. And then what we'll be doing is working with the BWR Owners Groups and probably two fleets that have lots of those plants. And I don't have to tell you who they are; you know. And we will then look at that plant and then say, okay, how is that plant different from its neighbor? Then let's do a sensitivity study.

For example, if you pick the plant that has a RCIC system, not an isocondensor, we'll then do a sensitivity study the other way around. Things like that. So we'll be using the BWR Owners Groups and the industry to -- by the way, the PWR Owners Group has consented, as well, so they're familiar with what's going on -- to identify what the differences are so when we do come up with here's what we think this tells us, how applicable it is around the industry. That's definitely the plan.

And we brief you about, you know, pilot plant. No one is interested in, you know, a sump strainer-style science fair. I've heard that from the staff. They're not interested, and we're not interested. But let's figure this out. Let's work the milestones, you know. And so we want to prevent that kind of -- what do you want to call it -- scope creep as much as we can.

CHAIR SCHULTZ: I call it a lesson learned, and I was hoping we would not repeat such lessons learned. I did want to just reconfirm again, because when I read the work that was done by EPRI and the way that, in that document, the capability of the event is described, it appears as if it meets the same definition that would be described as a severe-accident-capable vent. And I just want to --

MR. KRAFT: You're right.

CHAIR SCHULTZ: -- get that square that the intention and the work that has been done by EPRI is well understood by the industry that it would go beyond what was ordered already in terms of hardening the vent to an approach that would allow the vent to be considered severe-accident-capable --

MR. KRAFT: We have made that point to our Fukushima steering committee. And while I can't speak for everyone in the industry, I was talking to the responsible individual at one of the large fleets who said we already understand we have to do that. So I think the answer to your question is, yes, but part of the pilot plant pilot study is to then socialize all this information throughout the industry so there's uniform understanding as to what's required.

CHAIR SCHULTZ: And when you put the words out to say we understand we need to do that, is that, I'd like to believe that that was based upon an understanding of the EPRI work and an understanding that there's a real benefit to doing that in order to be able to say we have additional capability to respond to severe accidents if we get to that point.

MR. KRAFT: Well, I mean, we can't make commitments for every licensee, but that's certainly the intent. I don't think we say it any stronger. The chairman of our steering committee, Jim Scarola from Duke, has made clear to me and clear to, you know, the steering committee that we're going to do this right, you know, uncompromising. So I think the answer to your question is yes, and we'll just have to make sure that it's understood that way.

I don't know what the staff paper is going to say. And the last I heard, and I see John Monninger is going to look at me over here, the last I heard were four options. So if an option is severe-accident-capable vent, which I don't know what that is when it's at home but I understand that's the words they use, how is that an option? Unless your decision is to recommend nothing, no change, then --

CHAIR SCHULTZ: That's an option.

MR. KRAFT: I know that's an option, but I'm saying once you recommend any of your other options to have a filtering capability, either order a filter or performance based or whatever, you have to have the event capability the way you describe it. I don't understand how you don't myself.

CHAIR SCHULTZ: That's true.

MR. KRAFT: So I don't get, I just never understood how that was an option in this because what that said, as an option in this paper, you need the event capability to survive the accident. I don't get it. It seemed like a fairly limited application to me.

CHAIR SCHULTZ: Well, it fits into the

work that EPRI has done if, in fact, it's described and intended the same way. One concern would be that we would describe it that way in doing an evaluation and a study and demonstrating what could be done, but, in fact, what we have done is we've put in a hardened vent and the operators can't get to it to do those --

MR. KRAFT: No, but you can't do the controlled venting in the EPRI study without having a vent that's capable like that. And that goes to my point about how do you make the plants look like the study? So I see that as a natural occurrence, but your point is well taken about what the entire industry understands. I agree with you that you couldn't find everyone in the industry understands this because it's not been promulgated widely enough yet because there's no requirement. The studies have been done. Everyone, you know . . .

MEMBER CORRADINI: Can I ask a different question. I'm looking at this slide, and you talk about the tabletop pilot. So are you going to work this backwards in the sense that you're going to start off, or at least I would expect you to work it backwards, you start off with an overall system performance and then see what required design changes, SAMG enhancements, and filter considerations we would need to achieve that? I mean, the way you have it, it's linear this way. It seems to me, if you're going to do this --

MR. KRAFT: It's iterative, isn't it? Isn't it more iterative?

MEMBER CORRADINI: Well, maybe, but I'm trying to understand, because I'm looking at your last bullet, I've been reading it two or three times, and I think I get it. So you're going to have some sort of overall representative, and it has to be plant specific, but just some overall value at some sort of reliability, and then you're going to look at what might be needed to be done to achieve that with a particular plant under a set of particular SAMGs, etcetera, etcetera?

DR. GABOR: I think that's right. I mean, we identified in the EPRI report that, you know, a viable strategy had to provide at least a DF of 1,000, overall DF of 1,000, a 0.1 volatile releases of cesium, which we think is consistent with what we've seen in Europe 20 years ago when they were looking at these. That seemed consistent. So we wouldn't judge a strategy, a plant-specific strategy, to be really viable if it didn't at least achieve that objective.

So I think Steve is right. It is going to be iterative because there is some flexibility in the SAMGs. There ought to be. There should be. And we're going to probably iterate to see, you know, within the realm of what's allowed in the SAMGs and perhaps some enhancements to the SAMG, what works best and what doesn't. So I do think that we'll exercise a fair number of scenarios to better understand, you know, what works the best. And that might involve things like early containment venting. There are strategies prior to the severe accident where you could be venting early that the Owners Group has been looking at. Those things need to be rolled into this tabletop, as well, to see what kind of additional benefit does it provide. And we included a sensitivity in the report to say, prior to core damage, if you could keep the pressure low, and this is consistent with updates that are being done about to be rolled out on the technical basis report, and that is to try to maintain a moderately low containment pressure even prior to core damage event.

So I think it will be an iteration, but I do think that, you know, consistent with the EPRI study, we don't --

MEMBER CORRADINI: That's your starting point.

DR. GABOR: Our starting point is going to be you're pushing to get at least a DF of 1,000.

MEMBER SHACK: Now, I mean, you agree that you do need to do dry well venting in some situations?

DR. GABOR: No, I don't. I won't agree to that. I think there are strategies, and there have been some additional -- the reason we have to go to a dry well vent is because of inventory control. There may be other ways to manage inventory, and I've seen some of these. And the utilities are coming up with some of these strategies. So it's not a given, and what's interesting about it, depending on, you know, you can see the tradeoff. At first, you'd say, oh, the more gpm I put into containment the better. That's not always true because that's going to push you to that to quickly make the decision that you would require dry well venting.

But, again, in the analysis that we did, we saw that, you know, initially venting through the wet well brought the pressure down such that, yes, you would eventually get to a point where you had, if you needed to vent later, it would have to be through the dry well. But it turned out that the early venting and all the cold water you're putting in soaked up enough decay heat that your requirement to open that dry well vent got pushed way out in time, and you can see that in our report.

So I'm not saying dry well venting is a given. It's clearly handled in the SAMGs. It's addressed in the EPRI report. We'll see how it plays out with our pilot and the actual strategies.

MEMBER CORRADINI: Can I go back to your slides real quick? So these are just examples. There are other things that you would have to, that might come up on the list when you run the calculational experiment?

MR. KRAFT: Yes, absolutely.

DR. GABOR: We have seen a strategy to let down the torus, to find a way to pump water out of it.

MEMBER CORRADINI: Okay. Because that's exactly where I was going with it because, if you did that, then you'd have to have some sort of external place to put it, given all the stuff that might be in it.

DR. GABOR: Exactly.

MEMBER CORRADINI: Okay.

DR. GABOR: Exactly.

MEMBER CORRADINI: And then remind me about the fifth one about Mark II. I don't remember that and that geometry.

DR. GABOR: Yes. And we talk about this kind of generally in the report, but, as Steve pointed out, there's five sites that have Mark II plants --

MEMBER CORRADINI: And they're all different.

DR. GABOR: And they're all different. But one of the common things that we did see in four out of the five was that, at least beneath the reactor vessel in the cavity or pedestal region, was, you know, a collection system, a drain system.

MEMBER CORRADINI: It's empty. There's no water.

DR. GABOR: Right. But it involves a four-inch pipe or multiple four-inch pipes that go down through the diaphragm floor and likely take a right turn and exit out of containment. Some of them go into a hold-up tank that's still in containment. I think some of them may actually get pumped out. I'm sure, you know, there's isolation valves. But debris in a four-inch pipe taking a right angle poses a potential threat, melting. It's likely not going to stay coolable in there, so it's going to melt and create --

MEMBER CORRADINI: That's what I thought you were talking about.

MEMBER SKILLMAN: Let me ask this. In a tabletop exercise, how do you pick the plant? Here's an example. You talked about Cooper, Columbia, Vermont Yankee, Pilgrim, Peach. They're all different. They have different population densities, different economies, different types of land surrounding them. How is choosing one representative?

MR. KRAFT: Well, we're trying to represent the plant itself, not the surrounding community population density. We're not doing consequences calculations or anything like that. We're trying to figure out how do you operationalize in the plant these activities, so the selection is easier than you just described but it's really going to be picking a plant that is representative, initially, of as many as possible and understand what sensitivity analyses we have to do and then also picking a plant that the company is willing to put the resources into it on behalf of the industry. You know, there was a plant we talked about picking that, frankly, has been the subject of a lot of studies in the last two years by this agency, and I don't know whether they want to do it again, you know, because the plant has to, themselves, put resources into this, which is not to say they wouldn't be willing to. I'm just pointing out that there's a way to pick these things.

But the idea that -- we're not going to exercise the MACCS2 code part of it. We're going to be looking at the MAP code part of it.

MEMBER SKILLMAN: Just a minute here. I hear your words, but I'm not as comfortable as you are. If I'm going to be talking about SAMGs, I'm in the EALs. Now, if I'm in the EALs, I'm looking at doses and population. That's what's going to trigger the EALs, and the SAMGs are going to get me there. And so when you say they're really not connected, Steve, I don't share that point of view.

DR. GABOR: Well, let me try. As Steve said, we've picked our surrogate for offsite consequences, and that is achieving an overall DF of 1,000 or better, limiting the release of cesium to less than a tenth of a percent. So by picking that as our surrogate, we don't have to do the offsite planning work. We don't have to investigate. I'm not saying we're not. That might be another phase of this. But it doesn't affect the actions that we're taking to achieve a DF of 1,000.

MEMBER SKILLMAN: I can see that from inside the plant.

MR. KRAFT: Although, having said that, we did this afternoon on our planning call, we looked at it from the other way around. I mean, should we have an EP representation at the table, not so much for when you kick off emergency action or anything like that, but because, at some point, this activity does bleed out into that planning, as well.

MEMBER SKILLMAN: Absolutely.

MR. KRAFT: But you have to keep the scope controlled enough so you can get it done in a reasonable amount of time. The target for getting the first phase of it done, which is the feasibility, is to be able to have the industry discuss the results at the public meeting the Commission will have on that report probably in January. So that's not a lot of time.

DR. GABOR: I think the other thing, you know, the subject of the pilot was motivated by feedback we initially got from the staff when we presented the EPRI findings because, obviously, the EPRI analysis is I didn't have to worry about the reliability of the pump, I didn't have to worry whether the operator could successfully perform those actions. I just said they did, it worked. I'm a deterministic kind of guy. But the questions we got from the staff went beyond that and said, okay, we understand these strategies, but how can they be implemented, how successfully can they be implemented from equipment reliability, human actions. That's the focus and that's the product we want to get out of this pilot is to demonstrate that.

MR. KRAFT: For example, we'll have at least one license, you know, SRO at the table to talk to that issue, you know, as we work on it from that plant, you know, understands how that plant, whatever plant it is we pick.

MEMBER STETKAR: Jeff, you left yourself wide open. Rich isn't here. I'm not a deterministic guy. I'm kind of a probabilistic guy. One of the -- in terms of selecting your pilot plant, somewhere in your slides you make the note of representative scenarios. And when I think of representative scenarios, those are sequences of events that have frequencies assigned to them, and those frequencies account for the things that you said are not part of your world, you know, valve failures and human error probabilities and timing of scenarios and dependencies among human actions if there's a lot of manual things, the effects of external events on availability of FLEX equipment perhaps or the ability to connect it and so forth.

Are you going -- I would hope, because I'm a probabilistic kind of guy, that the pilot plant that you take would have a fairly well-developed PRA so that you can actually look at those scenarios so you don't rely on only, you know, pardon me, the deterministic guys to pick the scenarios that are interesting to them.

DR. GABOR: You know, we, as a group, we've been talking about, you know, we're still kind of formulating the pilot and what we want out of it. And there were initially some discussions about, well, we might want to see some probabilities playing in here. I don't think we're going to go there, but I do think, I do agree with you that we ought to, if this is a plant-specific pilot, we ought to take the insights that are coming out of the plant-specific PRA and at least make sure that the scenarios we're picking are consistent with what's driving risk for that plant.

Now, we all think we understand long-term station blackouts. We think we're going to cover a pretty --

MEMBER STETKAR: That's part of the problem, though. Everybody understands station blackout and everybody knows that's the worst thing that can possibly happen or that it's the most representative. In some cases, it's not. In some cases, there's a fairly high conditional probability that things that don't look like a station blackout with successful RCIC operation for, you pick the time, is the most important contributor. And understanding where in relative space those other scenarios are I think is an important perspective.

MR. KRAFT: One of the first things we talked about was initial conditions. It was exactly what you're getting at. So I think that is first on the list that --

DR. GABOR: Yes, I don't disagree with where you're pushing us. I think we do have to consider the insights from the plant-specific PRA. And, you know, we tried to do that in the EPRI study to some extent to look at, you know, even though we did focus on a station blackout, we tried to do things like, well, let's change the time at which RCIC can operate it, is that going to influence anything? And what if RCIC doesn't start? I mean, you know, what if we lost at time zero? So we tried to cover that. We didn't go out and look at a full PRA.

MEMBER STETKAR: And I think part of it,

you know, you can select scenarios, but without a context for saying, well, there's 75-percent probability that this is at the top of the heap, but there's 15-percent probability that the scenario might look like this, as opposed to, you know, 0.015-percent probability, is an important perspective, rather than just kind of selecting scenarios.

DR. GABOR: No, I agree. I think we have to be cautious of that, and we have to be paying attention. I mean, the only thing I'll say is from a Level 2 point of view. A lot of that stuff just really isn't going to change the outcome, so the strategies that we employ may not be sensitive to was it a LOCA or not a LOCA. They could be because fission product transport changes. Same thing with, you know, from a Level 2 PRA, we always, as you know, we always address high pressure/low pressure core melt. So those factors I understand we could have some sensitivity to, and we need to address that.

MEMBER STETKAR: But some of the integration, some of the transitions from Level 1 to Level 2 to SAMGs and so forth, especially if you're talking about severe initiating events, seismic events in some cases, other types. I mean, I use the seismic event, but other types of even internal initiating events that could get you to similar conditions and especially if you're talking about human actions, operator actions. Your operators don't know the difference between Level 1 PRA and Level 2 PRA. They respond to an event.

So some of the notions of, well, if there are scenarios that might benefit from early venting prior to core damage, not your ballpark, what's the likelihood that they would do that? And if they don't do that, you know, what's the likelihood that they would then implement in your kind of Level 2 space the actions that you're presuming that they would do following the SAMGs? That sort of integrated perspective might benefit, at least in terms of the context of --

DR. GABOR: Yes, I don't disagree with you.

MEMBER STETKAR: -- those representative scenarios.

DR. GABOR: And we made it clear up-front that we wanted PRA presence on the pilot for those reasons.

MEMBER STETKAR: Thanks.

MEMBER ARMIJO: Just a quick question. This pilot, how long will that take? Is it a one-year thing, two years?

MR. KRAFT: Well, the full pilot, we, back of the envelope, think is a year. But this initial part of feasibility, probably a few months in January, and then we'll determine, when we meet for the next phase, we'll be looking at specific systems and components; and the third phase will be what you do actually in the plant. So we're not committing -- we want to do the whole thing, but we want to be able to talk to the agency earlier. If we had to wait until the whole thing, we'd, you know, I don't think anyone would tolerate that.

One thing I want to mention, as we've exceeded our time here, Mr. Chairman, is that all this discussion we've had that involves how you put water on the corium outside the vessel applies whether you accept our notion of filtering strategies or an external filter because if you go back to the event tree you have to do that. You have to do all these things Jeff is talking about. And all the questions about how operators behave, how valves behave, all apply regardless. So it's not unique to what we're proposing as a performance-based requirement, performance-based approach. I just want to make that point because sometimes it sounds like, because we're talking about it, it's unique to what we're proposing, but I don't think it is. It has to be done no matter what. You could have a Mark II bypass directly into the dry well whether you've got a filter on the pipe or not. And so you still have to close up that pathway, so this kind of work is still needed.

DR. GABOR: Yes. The other thing I'll just add, I know you mentioned the additional slides we had. But Doug True put together an FMEA, and you can see from that we were asked a question, if not by you but multiple times by the staff, is if you had FLEX you wouldn't have core damage, so how can you then have that equipment to mitigate an accident. So the FMEA was to try to put some perspective --

MR. KRAFT: By the way, that's an extremely fair question. I mean, if you assume you have core damage, you have to assume FLEX didn't work for some reason, so how does FLEX now work? That's a key issue in our, in this pilot. I mean, how do you mobilize to people? Can you get the hookups? You know, things like that. But, again, back to my context, we're beyond design basis, so how you think about things is different and how you think about what's the appropriate thing to do is different than a design basis where everything is not easy to predict.

CHAIR SCHULTZ: And, Steve, the project managerial focus on the pilot study is the Owners Group?

MR. KRAFT: Yes.

CHAIR SCHULTZ: And their activity and their leadership which would drive it through the next steps and assure that there's --

MR. KRAFT: Well, BWR Owners Group is managing it. There's a heavy component from EPRI. NEI, of course, is involved. But the leader is from our Fukushima steering committee. The leader is Maria Korsnick, who is the CNO of Constellation. It needs that level of attention in the industry to get done right. We learned that lesson. And the way the industry function is when we have big issues like this we name an executive sponsor, and that's Maria. So that's where the management starts, and, you know, she's a pretty good taskmaster, I'll tell you that.

CHAIR SCHULTZ: Thank you. Other comments or questions from the Subcommittee? With that, I'd like to thank you, Steve, and you, Jeff, for the discussions. It's been very helpful in terms of understanding more than what we learned from the EPRI report and certainly our previous discussions and presentations, to thank you very much.

And with that, I would like to move into the staff's presentation. So a moment or two to rearrange chairs, but we'll move forward with this presentation and we'll pick an appropriate time to take a break later in the meeting. So with that, I would like to introduce Bill Ruland, who would like to make some opening comments and introduce the staff to us. Bill?

MR. RULAND: Good afternoon. Today, the staff will add to our previous discussions about the qualitative and quantitative factors. And we're going to add to that our recommendation for recommendation three, which is a recommendation for filtered containment ventilation systems.

As at our previous meeting, the qualitative factors in the cost benefit analysis were key, as we described at the previous ACRS meeting. Contrary to what you just heard from the industry that the staff regulatory analysis demonstrates additional filters is not justifiable, we believe we applied the backfit rule, as the Commission envisioned, for SRM. And, obviously, we know that this is a beyond design basis analysis of the beyond design basis event, as is virtually everything associated with Fukushima. So we understand that.

And in addition, you heard the description from EPRI and NEI about what their presentation was. The staff was aware of basically everything that the industry presented, and we encourage questions from the Committee specifically concerning the things that the industry said today. So we're prepared to respond to those questions and, hopefully, we will get a fruitful dialogue with this matter.

So with that, I'd like to -- John -- Bob Fretz, you want to get started?

MR. FRETZ: Sure, I'll get started. Thank you, Bill. Good afternoon, Dr. Schultz and members of the ACRS Subcommittee. My name is Bob Fretz, and I am a project manager within the Japan Lessons Learned Project Directorate. I'll be kicking off our briefing this morning. I will dispense from any other further introductions. I believe we have a number of members of the staff who will be presenting information in addition, as you see up here at the table right now. So I'll then dispense with that.

Again, we are here today to discuss the draft commission paper regarding the NRC staff's evaluation of options and proposed recommendations on whether or not to impose additional requirements for

BWR Mark I and Mark II containment venting systems. Our agenda is quite simple. I will provide a brief summary of the staff's tasking and schedule update. Now, again, the bulk of our presentation will be to discuss the draft commission paper, including the staff's proposed recommendation. As you know, the staff has been working under a tight schedule over these past few months. As of less than a week ago, our plans included a discussion of the most current draft of the SECY paper with the Japan Lessons Learned Steering Committee, and that meeting was scheduled for this past Monday. And the meeting that we had hoped to have was the staff had hoped to obtain the Steering Committee's endorsement of the staff's proposed recommendation or at least one of the other options based upon the review of the paper.

Unfortunately, Hurricane Sandy had something to say about our plans and schedules for this past week, so we were unable to meet with the Steering Committee prior to meeting here today. So, therefore, the Subcommittee should be aware that, when we do talk proposed recommendations, they are currently proposed recommendations. We have met with the Steering Committee a number of times. They've been generally supportive of the staff's recommendations. However, we have not received a final recommendation, so we hope to receive that shortly.

Again, our tasking really came to be from last December when the Commission told the staff that it should shift the issue of filtration of containment events from the additional issues category and merge it as a Tier 1 activity. In addition, this past August, the Commission directed the staff to include a discussion of accident sequences where filters are and are not needed as part of its Commission paper. We consider it our second tasking.

And, again, our current schedule. We first met with the Subcommittee way back in June where we had talked about the experiences and insights that we gained from foreign regulators, including Sweden and Switzerland, as well as Canada. We did meet in September to discuss the additional items and introduced some of the information of the studies that we got from our MELCOR analysis. And, again, we met as recently as October 3rd, I believe, where we had talked about some of our preliminary results from our MACCS analysis. Again, this is, essentially, a continuation of those meetings we've had with the Subcommittee, and I understand we're still on schedule to meet for tomorrow with the full committee.

And, again, I'd like to turn the rest of this discussion over to John Monninger.

MR. MONNINGER: Good afternoon, Dr. Schultz and ACRS members. My name is John Monninger. I'm the Associate Director of the Japan Lessons Learned Project Directorate in the Office of Nuclear Reactor Regulation. I want to thank you very much for the opportunity to brief the ACRS today on the staff's development of a draft commission paper, which you have a copy of, entitled "Consideration of Additional Requirements for Containment Venting Systems for Boiling Water Reactors with Mark I and Mark II Containments."

In developing this paper, the staff is providing the Commission with information options and a recommendation on imposing new requirements related to containment venting systems for BWRs with Mark I and Mark II containments. Specifically, the options presented include requiring containment venting systems capable of operation under severe accident conditions, containment venting systems that include filters within the control release pathways, and a performance-based approach to containment filtration strategies.

We've performed various assessments and analysis of the possible requirements for licensees to ensure that the containment venting systems are capable of operation under severe accident conditions. We've had numerous public meetings and interactions with the ACRS to date, and we thank you very much for your feedback and we have taken it into consideration and are fully prepared to discuss that today.

The evaluation of the options use existing NRC processes and address possible updates to our associated guidance documents, in particular the regulatory analysis guidelines. The evaluations also included consideration of several key factors that are not readily representative in quantitative terms, whereas a comparison of only the quantifiable costs and benefits of the proposed mods considered safety enhancements would not justify new requirements relating to severe accident containment venting systems. When these costs and benefits are considered with other qualitative factors, such as the importance of containment systems within the NRC's defense-in-depth philosophy, the staff concludes that a reasonable argument can be made to require the installation of filter vent systems for Mark I and IIs, and the staff is recommending such action.

Our presentations and discussions today will cover the staff's analysis and information used in developing our draft recommendation. We look forward to your questions and comments.

This slide summarizes the outline of the paper, which you do have a copy of. It's a draft internal NRC-only paper, but we are fully prepared to discuss it. And our presentations today will essentially run through the order of the paper.

The main paper provides an overview of our analysis. It includes a discussion of the licensing history of Mark I and II containments and how the consideration of beyond design basis accidents and severe accidents led to the consideration of venting. The potential need for venting under beyond design basis accident conditions and severe accidents for Mark I and II containments goes back to the early 1980s. As a matter of fact, the NRC approved venting back in 1982 for these designs.

So what you're talking about now is not whether the designs will or won't vent. What we're really talking about is whether the system structures and components within the plant can withstand what we've already approved. We've already approved venting. The question is now are we going to require system structures and components to live up to that?

MEMBER CORRADINI: Can I just clarify that statement?

MR. MONNINGER: Yes.

MEMBER CORRADINI: I guess I think I heard what you said, but I thought the equivalent in '82 was within the context of not in severe accident space but in before severe accident space. So the way you frame it there sounds a bit mushier than that.

MR. MONNINGER: So if you go back, the BWR Owners Group developed what's called EPGs, Emergency Procedure Guidelines. And the industry then takes those EPGs and develops the plant-specific EOPs. When you go into the EPGs and the EOPs, they are symptom-based issues: hydrogen generation, the containment pressures, the analysis supporting the development of the EPGs, and the staff's SER. It clearly discusses beyond design basis accidents, and it discusses severe accidents. It discusses the need to vent regardless of the accident consequences. It discusses the need of controlled venting, although very unlikely, is much more preferred to some type of catastrophic containment failure. So when you look at the NRC's approval of it, it explicitly did include severe accident conditions back in the 1980s.

MEMBER CORRADINI: Okay. Then maybe I'm mis-remembering it. It was my impression, though, that it followed the emergency operating procedures. The venting would occur before core damage.

MR. MONNINGER: I don't think --

MEMBER CORRADINI: I'm just pretending they did it right all the way through. That's what my memory is, so is that just wrong? I have it wrong?

MR. MONNINGER: Well, they're symptom-based procedures, so it doesn't say whether core damage has occurred or not. If you're in a long-term station blackout and you approach the primary containment pressure limit, you may not have had core damage yet. But if you're in a different accident sequence, you could. There's also venting provisions for hydrogen control, and the only way you're going to get hydrogen is from the severe accident. So any of your venting for hydrogen is from the severe accident, and those procedures currently exist within there.

So the whole issue with procedures versus equipment, the venting was approved, but it was recognized that they would use existing plant equipment or licensees could potentially upgrade equipment. Some designs, some plants may have had robust piping. Others may have had duct work, so that led to Generic Letter 89.16, which was to beef up the piping or beef up the duct work to what's called hardened piping.

MEMBER CORRADINI: Let me just proceed. I don't want to hold you up, but I want to make sure I'm clear. But the venting is a decay heat removal procedure. It's not a --

MR. MONNINGER: The venting can be used in all procedures.

MEMBER CORRADINI: But its only useful purpose is to essentially maintain containment integrity within a limit by essentially mass laws for decay heat removal instead of heat law. That's all it is.

MR. MONNINGER: You know, the venting is there to prevent the catastrophic failure of the containment. For issues like the TW sequence, the laws of containment heat removal, they would utilize those procedures and vent hopefully prior to core damage. For other accident sequences where you already had core damage, the venting was intended to be through the wet well, and there's discussions within, you know, within the basis for the EPGs and within the staff's SER talking about the scrubbing capability of, you know, of the suppression pool. But it also recognizes that there is the potential that they could vent through the dry well.

MEMBER CORRADINI: No, no, I was trying to make a -- I don't disagree with anything you're saying. I'm just saying that, I mean, from the standpoint of what it does, it's removing energy by removing mass instead of removing energy by removing heat. So it's really a containment, it's only that containment, some sort of catastrophic containment failure by essentially controlling pressure in a different manner. That's all I'm trying to say.

MR. MONNINGER: Yes. So we have four potential options that we will discuss. We did use our existing regulatory process. There were comments made with regard to whether qualitative analysis or qualitative arguments is consistent with our regulatory analysis guidelines. And, yes, it is consistent with our guidelines. If you look at NUREG/BR-0058 or 56, 0058, it talks about that. If you go back to the Commission's SRM from 1993 talking about the backfit rule, the Commission explicitly recognized the need to include qualitative arguments. With regard to the federal government, the notion when you do a regulatory analysis is you are to bring in all the costs and all the benefits. And if those benefits cannot be quantified, you are supposed to talk to them in a qualitative manner. So it is within our current regulatory analysis process.

Flipping the slide to slide nine, the options considered. The first one is no change to the current order which was issued this past March, and it's a reliable hardened vent for prevention of core damage. And what we mean there is we did not put any additional design consideration within the requirements of the order for severe accident conditions. We also did not specify whether the pathway for that venting order 12-50 shall be through the wet well or dry well. So licensees could, if they want, and we'll see the submittals this February, in response to the current order, their reliable hardened containment vent could be through the dry well, and that would meet all the requirements of the current order. There is nothing in there for severe accident conditions with elevated temperatures, pressures, radiological environments, hydrogen, etcetera, within the existing order.

So that takes us to the second potential option, to beef up or to add on to the existing order out there to explicitly address severe accident conditions. Should the valves be different? Should there be different duty cycles associated with the valves? Should there be shielding for operator action where the current valves are located? If they were to do it in accordance with 12-050, can they then do that now for a severe-accident-capable vent? It would also look at the routing through the reactor building. Would there be shine associated with venting post core damage?

So that's the notion of the severe-accident-capable vent. We actually look at one, two, and three as sort of building upon a foundation. So you have the foundation 12-050 there. We would add potentially additional requirements for the severe-accident-capable vents, and that then takes us to the filtered vents. From options one and two, you would then potentially add a filter, external filter on that pathway. So in the filtered vent, the design requirements would include the requirements in 12-050. They would also include the severe-accident-capable vent requirements, and then they would add on a filtered vent to the end.

The fourth one is the performance-based approach there, which could be -- whereas, options two or three would be, I don't want to say one size fits all, but it would be, generally, a deterministic requirement out there that all plants would meet, the fourth potential option out there would be to establish some type of performance requirement and allow licensees to come in and propose and justify a series of operator action, existing plant equipment, and enhancements to plant equipment to meet the performance-based approach. We would look at the fourth option as being some type of potential rulemaking, and it's also potentially in line with what NEI's letter earlier this month talks about.

MEMBER STETKAR: Are you going to talk a little bit more about option four in this presentation? I thumbed through the slides, and I didn't see any discussion of it. Are you?

MR. MONNINGER: We can. Yes --

MEMBER STETKAR: I would like to talk about it at some time, either now or let you get through all of your discussion of options two and three. And it's your choice of when we're going to discuss it.

MR. MONNINGER: Might as well do it now. I don't see any other --

MEMBER STETKAR: Okay. Quite honestly, as I read through the SECY paper, I couldn't follow your rationale for just sort of dismissing it. As best as

I can tell, you dismissed it because you think it would require rulemaking and you assert that NEI says that it would take a long time to do. Is that basically your conclusion of why you just basically dismissed it?

MR. MONNINGER: I don't think we've dismissed it. It isn't the recommendation. I don't believe we have dismissed it. I think --

MEMBER STETKAR: I didn't find --

MR. MONNINGER: -- there are good reasons --

MEMBER STETKAR: I didn't find a good well-structured rationale for why it basically is not considered.

MR. DENNIG: There are two considerations, I believe. Number one, and this is not quite to the point but it's been done before. It was done in Sweden between 1982 and 1985. They did that. They came out the other end. Utilities participated. They looked at all the assets in terms of sprays and floods, and all these things that are talked about in the EPRI study, and they came out the other end and they said you're going to need a filter, you're going to need an external filter. That's all very good, that's all to the good, but you're going to need an external filter. And the reason was because of the uncertainties in the analysis. The primary part was because of the uncertainties and the mechanistic analyses and the core damage progression analyses and the release analyses that just could not be set aside, and the filter had the advantage of not being sensitive to sequence, being useful for all-over pressure incidents. In the words of STUK in Finland, being useful for all situations where there are energy and fission products in the containment.

So because of the wide usage of it, and they did look at all-over pressure incidents and they did look at, specifically they were told in the law to look at alternatives as they were going through this program, they came out the other end you need a filter, it needs to do this. So the uncertainties, I think we've confirmed, looking through our own work, that those uncertainties are there, that a filtered vent has certainly been tested and proven to a degree beyond what you can achieve with the analyses; and, therefore, it's a superior choice from a technical perspective.

MEMBER STETKAR: I still didn't hear a rationale of why the performance-based approach wouldn't work where I design a filtration system and

I design an integrated accident management process on a plant- and site-specific basis that is not, and John used the term, one size fits all based on deterministic thou shall have this and everybody shall have this because we've determined deterministically that this will work. We've learned, for example, for risk assessment that this does not work equally well for everybody. This, for example, after TMI with specific reliability requirements on auxiliary feedwater systems without the knowledge that auxiliary feedwater systems are probably 10 or 20 different designs of auxiliary feedwater systems with different dependencies, different timing considerations, so that this didn't work for everybody. It wasn't the most effective solution to manage and reduce risk. And that's part of the problem of the one size fits all deterministic requirement that I don't see the sensitivity to --

MR. DENNIG: The rationale goes a bit farther into looking at the two components of risk, if you will: the prevent core damage and mitigate the core damage. The containment performs in a different way than the prevent core damage aspect. You can multiply two numbers together and have a small number and a big number, and you get the same number. But from the standpoint of design and the standpoint of performance, the containment can be made passive. It can be pretty stupid. It does not have to be very smart. It addresses a lot of things that you haven't thought about.

MEMBER STETKAR: And having done integrated Level 3 risk assessments for several plants, I've found that stupid passive designs are stupid passive designs. Sometimes, stupid passive designs don't work as well because you've not thought of all of the scenarios, you've not thought of the nuances of a particular plant, you've not thought of the nuances of the particular surroundings around the plant.

MR. DENNIG: One of the nuances of the Mark I is that when there's no threat of fission products in the containment under design basis, you're in good shape, so you don't need the containment, right?

MEMBER STETKAR: I'll give you that.

MR. DENNIG: So when there's a threat of fission products in the containment, you open it.

MR. MONNINGER: Yes. And I think that is where the staff looks sort of at the issue with the Mark I and II containments. If you look at the entire design, they have pretty robust injection systems, you know, primary systems, depressurization systems. There looks to be weaknesses in the containment design. And so the question comes in if you develop performance-based approaches and those performance-based approaches are so heavily tied back to the containment and uncertainty in the containment's response, and the staff thought about, you know, where are we going to go with this issue on testing, testing for sprays, testing for decontamination factors for the sprays, you know, flow rates, coverage, etcetera, you know, the suppression pool, the suppression pool temperature. And given all the various variables out there, the need for the plant-specific analysis, the potential need for significant research development and testing, we did not see the performance-based approach as being a short-term, you know, solution. We saw this as being an extended very comprehensive resource-intensive effort for quite a while.

MEMBER ARMIJO: But wouldn't you have the same requirements for a filter, the same testing requirements, the same kind of analysis, you know, all that you would put on the current systems? Wouldn't you put those on the filters and see if they met the goals?

MR. MONNINGER: And we've had meetings with at least three vendors out there, and we haven't seen the actual testing, you know, reports, etcetera. But there's been significant testing that has occurred for the various designs, and they've been developed over the past 20 or 25 years or so. And we've also put a level of respect or trust in the reviews and approvals that have been done of these filtering systems around the world versus we've asked the industry for information on testing for containment sprays and what would have to be done to demonstrate that. And certain things, the temperature of the suppression pool, the decontamination factor is a direct function of that. Are we going to be able to reliably predict the accident sequence that we're in? The decontamination factors associated with that existing plant are dependent upon that particular accident sequence. We view a filtered vent as being, to a large extent, independent upon the coupled reactor containment response during a severe accident, so that's -- I'm not sure if that scratches the itch.

MEMBER ARMIJO: No, it doesn't. It just seems that you put a lot of faith in these filters and these factory tests or laboratory tests and it's never been used in service and never been needed. You put a lot more requirements on the equipment and strategies in the U.S. plants, you put more, you have greater, let's say you lack confidence in those systems, but you seem to have a lot of confidence in the filters. And I just don't see where you get that confidence, other than the vendors say it works and other people have licensed them.

MR. DENNIG: Well, certainly, the first thing that we would have to do is write those specifications and then follow up to look at the testing. What we're saying is that outside the United States there is a very large database of design experience with filters. We stopped looking at filters in 1982 and, essentially, not followed that whole technology. So we could do it all over again. We could do all the testing and design over again, but it seems like we could benefit from what others have done and review that to the extent that it needs to be reviewed and adopt it to the extent it makes sense.

CHAIR SCHULTZ: The filtration systems that were installed a few decades ago on European plants, have they been upgraded to this new filter technology that has been described for you?

MR. DENNIG: The MSSV, which is the filter that was installed on the Swedish plants between 1986 and 1988 -- yes?

MEMBER STETKAR: Oh, the new one?

MEMBER SHACK: The Barseback one.

MEMBER STETKAR: The Barseback one is gone.

MR. DENNIG: Yes, Barseback was a big thing or rocks, and it was never duplicated. But during the program that was performed by the Swedish authority and their utilities from 1982 to 1985, they designed and tested scrubber technology, borrowing from coal-fired pollution scrubbing techniques, and that was the design that got installed between '86 and '88 on all the Swedish plants. So that's early or mid 80s technology. They haven't upgraded that system on those plants.

Follow-on filter design have basically shrunk down the size of the equipment and still using a scrubber technology, a Venturi scrubber technology, and there are some dry filters that we've heard about. But they have built on that. Basically, the size has gotten smaller. The testing has gone on through that development. The vendors assert that they can achieve very, very high DFs, which, essentially, aren't really necessary. In fact, they're not necessary. The Swedish authority determined that above 2,000 to 3,000

DF it was neither here nor there, so it really didn't matter. And the MSSV was designed and tested at 1,000. And procuring what is on the market today, we can't really, you can't get less than 1,000. You can get less capacity. You can get something that will take less decay heat. You can get something that will assume a certain level of processes in the containment to remove heat and scrub, but it would be designed basically from scratch.

CHAIR SCHULTZ: Okay, thank you.

MR. MONNINGER: So the next slide. You know, in looking through the combination of our quantitative and qualitative analysis, we believe that the best potential recommendation to the Commission is to require the installation of a filtered vent, and that's option three. So we wanted to bring that up front within our presentation, so, you know, as opposed to wait to the end, so your questioning, so you know exactly where we're coming from.

MEMBER ARMIJO: And just for the record, I asked it previously but I'll ask it again, option three really includes option two?

MR. MONNINGER: Yes.

MEMBER ARMIJO: So it's a combination of two --

MR. MONNINGER: It's actually option one, two, and three.

MEMBER ARMIJO: Option one is already there.

MR. MONNINGER: Yes. We are -- the one slide says there's Enclosure 7 which is draft orders, which you don't have a copy of and we don't have a copy of it either because we're still working on it, but it starts with the language from the existing order. And if you were to look at Enclosure 7A for option two, it would take the current language plus add some additional design requirements. And then if you were to look at option B, which would be the filtered vent order, it would then start with 7A, which is 12-050 plus severe-accident-capable vent, and add additional design parameters for the filtered vent. So it's a series maybe. It's a combination.

And then our thought with regard to the option four, the performance-based approach, if that was the preferred option, there may be logic in there that says, all right, performance-based option four rulemaking down the road, but in the short-term it looks like that there's general agreement that the current venting system should be designed for severe accident conditions. The Commission may wish to, if they were interested in option four, to also require the near term upgrading of the vent path to make it severe accident capable.

MEMBER STETKAR: So the presumption would be option four would involve two?

MR. MONNINGER: Yes.

MEMBER STETKAR: Essentially, there's no way of getting around two.

MEMBER SHACK: Two would be done in short order compared to four overall.

MR. MONNINGER: The staff would propose that.

MEMBER SHACK: But you always base the comparison of option three with option one. Why not compare it to option two?

MR. DENNIG: One reason is that, while we think of it in terms of a progression of functionality from a TW sequence event to a more fission product severe accident vent to a filtered severe accident vent, it's not entirely clear that you would start with what you have now as a Mark I and then add to that to make it severe accident capable and then add a filter to that that you would necessarily use what's in place in actually implementing the different options. There are Mark I plants that have their current 89-16 hardened vents intertwined with their standby gas treatment systems. They have circuitous paths. They have valves sitting on top of the torus in the torus room. So it's not clear -- you know, you can think of it in terms of I've got that now and in a little while I'll get that and now in a little while I'll get that. I think you're going to have to stand back and look at where you eventually want to wind up, and a straight piece of pipe from one place to another might make a whole lot more sense than trying to work with what you've got there.

MR. BETTLE: Especially with the filter being a more sizeable component in the system and, in large part, dictate where pipes have to be routed to get to it.

MEMBER SHACK: No, I just meant in terms of the cost benefit analysis, where it seems like you get a lot of benefit from option two at a relatively low cost compared to option three.

MR. MONNINGER: And then there's our quantitative analysis and our qualitative analysis. So when you were, if you were to go from two to three in our quantitative analysis, we assumed a decontamination factor of 10 for the filters. MELCOR calculates certain decontamination factors, etcetera, the same as the MAP code. But, you know, and if one was to believe those plant conditions at the time, the potential additional benefits from the filter may not be that great. So, you know, if you were to use the quantitative analysis, there probably wouldn't be that much of a difference, and I think that's where the qualitative arguments come in. The qualitative arguments are what sort of takes you to option three, this notion of another tool in your toolbox, a notion of a potential design fix that is independent of your primary system and your containment intertwine. So it's probably predominantly the qualitative arguments that we currently have that takes you from option two to three versus the actual quantitative analysis.

You know, the whole issue with dry well venting, when we did all the analysis we didn't do an integrated analysis based on time of, you know, the first 70 percent of the venting is through the wet well, but by that time they had flooded up in the remainder 30 percent. So this issue of dry well venting came up, you know, rather late on us. So we tried to consider that in a qualitative manner. We're not saying it's a definitive. But one of the issues with the containment design is its small size, and a lot of these issues just come back to its sheer small size and, you know, the non-condensable gasses impact it and also the flooding impacts it on that. If you look at units two and three at Fukushima versus unit one, you know, all the measures in the first couple of days to add water, thinking you're on a success path, you know, whether it's RCIC, HPSI, and a recirc, or if it's the fire trucks. You know, all those fire trucks are adding mass, and that mass eventually gets to your suppression pool and eventually fills up your containment. And it's not a ton of time between when you start injecting, and it's based on the flow rate, of course, when you would have to move from wet well venting to dry well venting.

So, you know, we did not, in our regulatory analysis, throw in the dry well venting because we'd have to assign some type of numbers there and some type of probability to that, and we didn't want to get caught up in arguments with regard to the staff defaulting to very low probability events. So we intentionally did not put that in our analysis, but we do think there is the potential there.

I mean, it's not only that, but there are differences between MAP and MELCOR, the issues with whether the entire core comes out of your vessel or whether some of the core is held up and late volatilization of the fission products and the releases. Once you move from the wet well to the dry well, you know, the EPRI analysis, it assumes it's essentially a clean release coming out there. But, you know, later on in the accident you can have heat-up of structures within the reactor within the containment.

There's also issues with ex-vessel interactions. When the core is on the floor, is it coolable all at once and there's no core concrete interaction and there's no additional hydrogen generation? I mean, there's some fundamental differences between what NRC's codes will predict and the industry code will predict.

MEMBER REMPE: John, if you don't have some sort of performance-based analysis done, how will you define the requirements for the filtered vents in option three for testing, like Sam was mentioning? I mean, you've got to have some sort of assessment. I mean, it's more than just the decontamination factor but how well will it perform for down to what range of events. And how will you come up with that?

MR. MONNINGER: Right. Well, a lot of it, you know, and we're still putting together the draft order now, but we believe it would have to specify the fission products, the releases coming out, the gasses, the aerosols to be scrubbed out, etcetera, and a decontamination factor --

MEMBER REMPE: Seismic capability --

MR. MONNINGER: We have to include, you know, consideration for seismic, for EQ, etcetera. That's not to say it would be seismic category 1, but they are things that we explicitly need to address. You know, does it have to be safety-related or not? Does it have to be seismic category 1 or not? Does it have to meet Appendix B?

MEMBER STETKAR: Remember the seismic events that get us into trouble are way beyond seismic category 1, so be careful there. If you're not going to design it for really big seismic events, you might as well make it non-seismic because it's going to fail.

MEMBER SKILLMAN: Those last several items that you identified are the ones that we wrestled with in the months following TMI, too. Is it safety grade? Is it Appendix B? Which reg guides do we use? Is it 1.26, 1.29, neither? Do we use the 1.114, waste or whatever it was? And those are showstopper questions when it comes to the costs of this thing because it isn't too hard for me to get the ASME Section III class 2 seismic 1, just like everything else that's supposed to be ECCS. We never asked that question when the vendors were up here, but if you go down that path I've got to think that it changes the costs to the point where one might say it simply can't be justified, it is just exorbitantly expensive. So I think you should say some more about that right now.

MR. MONNINGER: Yes, and we believe we have to go through -- and the difficulty is we haven't finalized on those issues. But with regard to safety-related, we've asked what they have done in other countries, and it's not a safety-related system structure or component. It's seismic category 1, but it is not a safety-related system structure.

MEMBER STETKAR: They're robust in the other countries seismically.

MR. MONNINGER: And in terms of cost, we've asked for cost numbers, and the best cost numbers we've gotten has been from the foreign countries, and that's the value of 15 million. We heard informally from industry, well, the price doubles if the filter has to be put into a seismic category 1 building, so that's the 30 million. At the last ACRS meeting, Dr. Corradini said, well, he's heard it three times the cost, and so that's why we put the 15 to the 45, but we don't have reliable cost estimates at this time besides those that have been provided by other countries who have installed them, and that's the $15 million value.

MEMBER STETKAR: I think, in some cases, the other countries were fortunate. Because of other requirements, they had robust structures adjacent to their containments for bunkered, you know, independent cooling systems that had some extra space in it. So they were fortunate. I've seen several installed in those locations where we don't have that here.

MR. MONNINGER: The next slide. So the basis for the proposed recommendation option three, we believe it's a cost-justified substantial safety enhancement based on both our quantitative analysis and our qualitative analysis. In particular, the qualitative analysis we believe it substantially enhances defense-in-depth for the Mark Is and the Mark IIs. It addresses containment vulnerability, you know, in particular the high conditional containment failure probability. And it also provides an independent means to address severe accident uncertainty. And the last bullet there, it provides a system that is independent of the coupled reactor and containment response.

MEMBER SKILLMAN: John, just for the sake of discussion here, supposing it cost $100 million, supposing it cost as much as changing out steam generators, a big project, a lot of radiological issues, a lot of plumbing issues, a lot of containment boundary violation issues, a lot of work to heal all the undoing that you've done, if it were to cost that much, how does that affect what you're presenting on this slide?

MR. MONNINGER: So on that, we'll get there in three slides.

MEMBER SKILLMAN: Okay.

MR. MONNINGER: How about that?

MEMBER SKILLMAN: Fine, thank you.

MR. MONNINGER: Hopefully, it will scratch the itch in three slides.

MEMBER SKILLMAN: Okay.

MR. MONNINGER: So we're at Enclosure 1, the evaluation of the options. The Commission paper is actually written at a very high level, and it pushes a lot of the details in particular to Enclosure 1. And it's a summary of our considerations and the decision-making process. It includes the results of the quantitative analysis, the MELCOR, the MACCS results, the PRA, the foreign experience, what we believe with regard to the various decontamination factors out there. And it also brings in the qualitative arguments.

The second bullet there, consideration of adequate protection. The NRC and the NRC staff, when we go about considering additional requirements, the first thing we should do is ask is this needed for adequate protection? We looked at the NRC's historical use of the adequate protection standard, and we looked at what we're trying to do to address residual risk, and the staff came down to a view that it's, the NRC has historically, to address these types of issues, pursued the substantial safety enhancement type of improvement, as opposed to trying to invoke adequate protection. Adequate protection has generally been reserved for issues associated with design basis accident, some beyond design basis accidents. Within the severe accident world, we generally have not pursued residual risk issues invoking the adequate protection standard, but we did look at that.

The Commission, of course, is the ultimate decider. They could look at it and they could make a decision that we view this as an adequate protection, or they could look at it as saying we believe nothing at all is needed or, in other words, option one.

MEMBER ARMIJO: But just to be clear, the staff is not saying it is an adequate protection issue?

MR. MONNINGER: That's correct. That's correct. Or our recommendation would be based on a substantial safety enhancement, which would include both qualitative and quantitative arguments.

So the next slide summarizes the quantitative analysis. So on the second column there, the severe accident capable vent, that's the option two. And the third column is the filtered vent. The total cost of the modification, including the industry cost and the NRC cost. The NRC cost associated with licensing inspection reviews. The industry cost associated with the initial installation, plus routine maintenance and operations costs.

We looked at a baseline core damage frequency of two times ten to the minus fifth, and we propagated that through, and you have your benefits and your net value. As a sensitivity study, we increased the core damage frequency by a factor of 10. So you can see that the potential cost benefit analysis is sensitive to your CDF. And there is a footnote there, and it relates to Jeff's discussion earlier with regard to the Mark II containment designs.

So option two, the severe-accident-capable vent, with this drain line under the pedestal, that represents the potential for suppression pool bypass. If you were to proceed with the severe-accident-capable vent, that bypass pathway invalidates the benefits of a severe-accident-capable vent. So the staff's thoughts are that, for the Mark II containments, for option two to be an option, we would also propose additional requirements to address that issue.

So in there we say that the cost for the Mark IIs are expected to be higher. You know, we believe that there are potential solutions out there. If you look at the ABWR, for example, they have sumps within the lower dry well, and there's two different sumps. There's a floor drain sump and an equipment sump, and they essentially build houses out of refractory bricks to protect those sumps. So we believe something can potentially be done for the Mark IIs to address that issue of suppression pool bypass.

CHAIR SCHULTZ: So here, John, I understand that here's the quantitative part of the discussion, and we're not relying heavily upon it.

But we do present it, and in the summary of justification we say on the quantitative and qualitative features we agree that this is a way to move forward. And I wanted to go to Bill's point with this slide up here, and that is with regard to the evaluations as shown, if we look at the filtered vent, we see that, we do see that for the case where we go to a very high frequency, two times and four per year, that we show a barely demonstrated benefit to cost balance. But that does presume that we have done the severe-accident-capable vent as well as the filtered vent.

MEMBER STETKAR: The way that it's done in the PRA is the vent works under severe accident conditions, and it's just whether it's filtered or not. So the PRA doesn't really, the risk assessment input to this doesn't really compare three to one differently. It's two plus three.

MR. MONNINGER: The cost of the severe-accident-capable vent are within the cost number for the filtered vent.

CHAIR SCHULTZ: But I'm looking at the benefits. The benefits associated with filtered vent incorporate the benefits of the severe-accident-capable vent; and, therefore, if you were to look at this sequentially, you would say that, yes, the cost benefit evaluation for the severe-accident-capable ventilation system is shown here. But if you said I'm going to do, I'm going to do option two, then you would get these benefits. If you say you're going to do option two, and then you say and in addition I'm going to implement the filter, then the benefit you get from the filter is the difference between what you show here and the result with the severe-accident-capable vent.

So really the bottom line for option three, in comparison to option two, is that delta of the benefit. In other words, half the benefit is coming from the severe-accident-capable vent, a little more than half of it. So your looking at what am I gaining by doing the filter biases the presentation a bit.

MR. MONNINGER: And part of that is in the way that we modeled it. Within our MELCOR and MACCS model, we, for the good or for the bad, we only assigned a decontamination factor of 10 of the residual release coming out of the wet well. So the MELCOR analysis, similar to the MAP analysis, provides, you know, a fair amount of fission product scrubbing for that particular accident sequence. So our benefit there of the filter is only that additional decontamination factor of 10.

CHAIR SCHULTZ: So that could have been assigned a higher value.

MR. MONNINGER: But then there's things if you were to assume that all the risk goes away, you could do a simplification where you would just take mod zero and, you know, you could take all the risk away, and the number wouldn't be significantly greater.

MEMBER STETKAR: I think somewhere in the report it says they looked at that and it still didn't work out.

MR. MONNINGER: Yes, because that's the way they do a lot of times. They assume it's perfect. But built in that perfect system where we're assuming the risk goes to zero is a high level reliance upon what you believe the suppression pool temperatures are, the pathways, the depositions, the plate-outs, you know, within the containment.

CHAIR SCHULTZ: I just wanted to be certain that, as it's presented in the document to the Commissioners, that it's clear that what is shown here is the benefit of both the severe-accident-capable vent and the filtration added to that. If I'm going to look at passenger safety, I can buy seatbelts or I can buy airbags. And if I buy both of them, I might be able to justify a certain amount. But if I'm looking at both of them together and then I look at them individually, the seatbelts might cost very little and give me a huge benefit and I may not want to spend the extra money for the airbag.

MR. MONNINGER: And that also goes into where our qualitative arguments and taking you from option two to option three. So the next slide. So the next slide, the things that are plotted aren't on there precise. It's meant more as a schematic to say, mentally, what would it take, based on my quantitative results, what would it take to walk me across the line to be cost beneficial? You know, and these are the two lines. This is the 15 million line and the 45 million line, and you could draw a $100 million line. And based upon the staff's current, you know, quantitative analysis, you know, the CDF and CDF, what does it take to move from this point to above here or above this line or above the $100 million line? What is the strength, what is the value or the reliance you're putting in those qualitative arguments to mentally walk you across that line?

MEMBER STETKAR: And on this, your

previous slide and most of the comparisons that are made looks at, horizontally isn't shown on here, two times ten to the minus five up to two times ten to the minus four CDF. But if I take that two times ten to the minus five and move up, it says if the economic consequences exceed, pick a number, somewhere in the range of $30 to $40 billion, even at the lower core damage frequency, it would show cost-beneficial. Is that the right way for me to interpret --

MR. MONNINGER: Yes.

MEMBER STETKAR: -- what I'm seeing? Okay. Thanks.

MR. MONNINGER: And within the pervious slide and this one, some of the benefits for the filtered vent would come in if you were to ever potentially go to the dry well venting, and we did not try to quantify that at all or at least include it in our quantification.

So that takes us to our next slide, slide 15, our potential or our proposed qualitative arguments.

CHAIR SCHULTZ: John, before you go forward, I think this is a good time for a break, and I think it's a good place in the presentation. It will give us some time to reflect on the quantitative evaluations which we've heard and prepare ourselves for the qualitative discussion. So I would like to take a break now, and I would like to return at 3:25.

(Whereupon, the foregoing matter went off the record at 3:07 p.m. and went back on the record at 3:26 p.m.)

CHAIR SCHULTZ: I'd like to call the meeting back to order. And, John, if we can pick up where we left off, moving into -- it looks like you've got a different slide up where you'd like to start, perhaps to introduce the connection between the quantitative and qualitative analyses.

MR. MONNINGER: We did do a little bit of brief caucusing, and there were two items I did want to mention prior to the qualitative arguments. You know, up front, we talked about the Steering Committee, and just to make sure the ACRS members are clear, the NRC Steering Committee, the Japan Lessons Learned Steering Committee, fully supports option three, recommendation three, the recommendation for the filtered vents. They just have not weighed in on the specifics of the order yet. So, you know, we have met several times with them to cover recommendation three, and the Steering Committee fully supports recommendation three.

The second topic, and, unfortunately, Marty is not here, but with regard to this, we also did an uncertainty analysis, and this was more the point estimate. But when one looks at the 95th, it also approaches, and that's within it. Your 5th and 95th percentile also --

MEMBER STETKAR: I was going to ask -- well, I'll ask it now. I didn't see that in 5C, the vertical differentiation. I saw the horizontal.

MR. MONNINGER: We did do the uncertainty analysis --

MEMBER STETKAR: It said that you did it, but I didn't actually see any results from when you did it because I could at least run out distributions and see where you were on the horizontal axis in a sense.

MR. MONNINGER: Well, how about we'll get that for the full committee and we'll bring it in and we'll show them --

MEMBER STETKAR: That would help because I was looking for it and I didn't find it anywhere.

MR. FRETZ: Let's put that on the list to discuss tomorrow. That would be very beneficial.

MR. MONNINGER: So then rolling into the qualitative arguments, we identified 10, 11, or 12 or so. There's others that could potentially be considered, and these are the ones that we put more weight on and they're discussed in the back end of Enclosure 1. Many of these arguments, in the staff's view, support the notion of additional requirements, whether that's option two, option three, or option four. However, some of these arguments would be against, some of these qualitative arguments argue against imposing additional requirements, and we wanted to include them for the Commission's consideration. And we'll go through those in the next several slides.

The first one, and this is the preponderance of the staff's argument, is the notion of defense-in-depth, in particular for the Mark I and Mark II containment designs. We do view these containments as being outliers than the rest of the fleet within the U.S., and the containment has always been recognized as an essential element of the NRC's defense-in-depth policy. They do have a very high conditional containment failure probability. And if you look at the accidents that did occur in Japan, that's what our analysis over the years would have predicted also.

The filtering, if one was to go with

option three, it compensates for the loss of the containment barrier. We believe that significant fission products would be withheld within the filtering to essentially reach a conclusion that defense-in-depth for the containment has been underscored. It also improves confidence in utilization of that so that operators could address other challenges.

It's been discussed the notion of operator actions for filters or for venting systems versus for cavity flooding, and it's true, you know, that operator performance is required for both. Within the filter path, you could have a ruptured disk to make it more passive. But if you look at the PRA that the staff did include within Enclosure 5C, there's a change in the conditional containment failure probability. And, you know, whether that number is currently 0.8, 0.9, 0.95, wherever it is, the staff did an assessment with a manual venting system or with a passive venting system. And even though the reliability that the staff assigns to the passive venting system is significantly higher than the manual venting system, you still see CCFP out there of around 0.3 or 0.4. And what's that then is dominated by is the notion of operator performance for cavity flooding. We assigned a 0.3 to the failure for cavity flooding in there. So if, you know, you can, as industry pointed out, you need both. You need a cavity flooding system and a vent.

MEMBER STETKAR: I wish you hadn't brought the numbers into it. I was going to wait and let you get through this, but, sorry, you walked into it and I might as well say it now. Yes, indeed, you did. Cavity flooding through the portable FLEX equipment is evaluated only during scenarios when the vent is available because, obviously, you need both. It's difficult for me, as kind of an ex-operator and people who have looked at emergency procedures, to say that if, if I'm an operator and I'm following my severe accident management guidelines and I've opened that vent manually, I pretty much know what I'm trying to do. Now, it's hard for me to understand now why I'm very likely to fail to get the pump going. And in the little model, they're treated as conditionally independent numbers, 0.3, from some SPAR HRA that doesn't account for timing or dependencies or anything. So this notion that, you know, operator actions do not get flooding are an important contributor I think it is an artifice of the way that you did the analysis, quite honestly. If they're successful opening the vent, they might be limited by the hardware of the pump, but that's a lot better than 0.3 failure. And that's where you get into the kind of scenario-specific performance, if you want to call it that, analysis of what's going on in these things.

MR. MONNINGER: And then using that number, that actually diminishes the potential value of the containment vent. If you were to use a higher value for human performance, higher likelihood of success, it would have made the analysis even more positive. It probably would have --

MEMBER STETKAR: It would have made -- you're absolutely right there. I mean, when we get into the PRA, I'm going to discuss a couple of things that are more appropriate to discuss in that content. You're absolutely right. It would make the vent look better, but it would have made the passive vent not incrementally as beneficial as might be implied from this analysis. This analysis is biased in a sense to say that a passively-activated vent is the way you want to go, and it's not at all clear to me that that's the appropriate conclusion. That's not in the SECY paper, but it's hovering right below the surface in terms of when you start thinking about design options. So there's two parts of the PRA in terms of what benefit do you get, vent versus no vent, filter versus no filter. And then it's this passive versus active or manual.

MR. BETTLE: But it wouldn't be an either/or, you know. You can have a passive, and you can also have an active.

MR. MONNINGER: Right. The staff has proposed, essentially, parallel paths of passive and then --

MEMBER STETKAR: I'll let you get back to the --

MR. MONNINGER: Okay. So the next slide, uncertainties. There's, of course, the known uncertainties out there, and then there's the unknown unknowns out there. We believe that the filter, in this case, would go a long way to addressing uncertainties, uncertainties with the event frequency, uncertainties associated with the consequence calculations, uncertainties associated with core melt progression, and uncertainties associated with the economic consequences modeling out there. We did do some studies, we did do some analysis out there trying to quantify some of these uncertainties, but they are not exhaustive.

The next slide, international practices.

A very high number or a very large percentage of the nuclear countries around the world have already installed or have committed to installing filtered vents. You know, from the extraordinary meeting, the members agreed to the statement that member countries should look to the need for filtration strategies to improve the containment performance.

If you go back to the Commission's SRM in 1993, they talked about one of the potential qualitative arguments that could be used is consistency with international standards. Now, filtered vents are not an international standard. There isn't an IAEA tech document or standard out there that requires filtered vents. But, nevertheless, their consistency with what the rest of the world is doing is one consideration in a qualitative argument.

MEMBER ARMIJO: Is that a very strong consideration for the staff?

MR. MONNINGER: No, our strongest one is defense-in-depth. You know, and, actually, our second and third one is also defense-in-depth.

MEMBER ARMIJO: Okay. Well, I think that's very important because I think NRC is a U.S. regulatory body. It's not, it doesn't have to go along.

MR. MONNINGER: Without a doubt, that is true, yes.

MEMBER STETKAR: John, and I don't know the answer to this, do you know what the Russians and the Chinese, what their position is regarding this? When you say most European countries --

MR. DENNIG: I think we sort of know but not very definitively. We have heard about China from a number of different sources about plants, to filtered and non-filtered plants. The last thing that we heard was that the decision was made to not build plants inland and just build plants on the coast. That was one way of handling this. Now, I don't, you know -- we had heard that they were fitting filters on new built plants, and we have seen pictures of those filters. They will fit inside a building, actually. They split it into two pieces. But the extent to which they're doing it and what their official position is --

MEMBER STETKAR: I was just curious, you know, in the context, kind of the high level --

MR. DENNIG: Yes, we don't know. There are VVERs that have filtered vents on them. Whether they're Russia, Ukraine. I think Ukraine still hasn't made a decision.

MR. MONNINGER: The next slide, slide 19, severe accident decision-making. The three options, options two, three, and four, we believe all of them provide enhanced potential for severe accident management. The notion of using the existing reliable hardened vent and putting a high-level of confidence by the operators in using it and post-core damage, we think there are issues associated with that. And as a result, if you were to upgrade that system to, as a minimum, a severe-accident-capable vent would allow operators to focus on other recovery actions at the same time. We believe the filtered vent system is the potential simplest solution out there.

With regard to the performance-based approach, option four, it could be also, as Mr. Stetkar mentioned, it could be integrated with other efforts that are ongoing out there, though we do believe or we would require, if a filter was required, they would then have to incorporate that within their emergency operating procedures, SAMGs, EDMGs, etcetera.

Emergency planning. The NRC, as the third tier of defense-in-depth, requires a robust emergency planning system. And to a large extent, the filters or the severe-accident-capable vents or the filtered vents, you know, one of the reasons why the benefits aren't necessarily as high is because the releases are occurring after the evacuation has occurred. So there's a residual population of 0.5 percent that we assume within the analysis that, for one reason or another, does not evacuate. A lot of the dose comes from the time period from when the population returns home.

So, anyway, we believe that there is merit in looking at emergency planning and the benefits of a filter for emergency planning. There could be different protective action recommendations issued if one knew you had a filter, if one knew you had an engineered safety feature that you had a high-level of assurance for scrubbing the fission products out of. We believe it would facilitate emergency planning more than a potential severe-accident-capable vent. We believe there would be a higher level of assurance in a potential release, a potential higher scrubbed release coming from the filter than through the unfiltered vent pathway.

CHAIR SCHULTZ: It's an interesting point you raise, John. I mean, it appears obvious, but I think it's a good feature to document appropriately.

So I'm glad it's included. Can you go back one slide and just, looking at that second bullet, I was interested in why, if you could go over it one more time why you chose the phrase that filtered systems are the simplest. The word simplest struck me, and I couldn't figure why it was chosen.

MR. MONNINGER: If you were to look at, potentially, option three versus option four, the containment has historically been viewed as a passive structure. You know, containment sprays are active. Your containment building, your torus, your dry well, your wet well, is essentially a passive structure. You want it to isolate -- well, you know, a strategy reliant upon cycling of valves, you're fundamentally changing your containment from a passive structure to an actively-managed system.

MEMBER STETKAR: John, you say it's passive. It's passive for design basis accidents. They've never been passive in that sense for beyond design basis accidents.

MR. MONNINGER: Well, the notion has been you open the vent pathway --

MEMBER STETKAR: Oh, okay.

MR. MONNINGER: -- but do you, you know, do you open and close it, open and close it several times an hour or multiple times within a 24-hour period?

MEMBER STETKAR: I see what you --

MR. MONNINGER: You know, are you actively monitoring containment pressures, suppression pool level for flood-up, and then transitioning between wet well venting to then dry well venting. It becomes more of a, I don't want to call it an active system, but it becomes more of an actively-managed system --

CHAIR SCHULTZ: I think that's a good way to describe the difference that you're proposing here, that one is relying upon active approaches by the operations crew, facility management, versus filtered system. In that regard, I understand the phrase simple. Thank you.

MR. MONNINGER: So we mentioned emergency planning, the potential to have different types of protective action recommendations. You know, to a large extent, you know, emergency planning, what are the weather patterns, the wind blowing, the rain, etcetera. You know, the timing of venting would not be as dependent upon the success of those if one had a filter.

Hydrogen. Maybe the word "clean" here will get us the same place as "simple" in the other slide. Improves operator confidence in a clean release for hydrogen control. Both options two and option three and most likely option four also would address hydrogen. You know, you want the hydrogen to be removed from the wet well and the dry well and released into the environment to prevent any types of threats.

You know, one consideration in here with hydrogen is the notion of the containment seals. And, you know, for the hydrogen to be released from the dry well to the reactor building, there has to be hydrogen there, but then there also has to be a forcing function there.

And that also gets into the notion of keeping your containment at elevated pressures and cycling it. You know, the staff believes, to a large extent, with the filters particularly, it could go a long ways to addressing the hydrogen issue, the hydrogen issue for the Mark Is and Mark IIs. If there was a filter there, you know, you could potentially reduce pressure to close to ambient pressure and have a high level of confidence that all your radionuclides have been significantly held up in the filter, as opposed to the long-term, you know, holding up your containment from 45 to 65 pounds or whatever, and having that driving function for the hydrogen and the high temperature through your seals. So the staff, you know, as documented within the Commission paper, we discuss what we believe to be the benefits of an appropriate system in addressing the hydrogen, the Tier 3 hydrogen control issue. There's other sequences out there, like containment bypass or IS-LOCAs that we know within the paper we would have to address to a large extent.

This is one of the potential cons, the severe accident policy statement that the NRC issued in the 1980s in response to the TMI accident. The NRC had an integration plan for a closure of severe accidents, which include the IPE, the IPEEE, SAMGs, improved plant operations, a severe accident research program, etcetera. And it talked about the generic need, there was no longer the view back then of the need for additional generic severe accident design features placed upon operating plants. You can argue that what we would potentially be doing today with options two, three, or four is counter to the severe accident policy statement.

MEMBER ARMIJO: That's independent of the options.

MR. MONNINGER: That's independent, right.

But you could also argue what we did with FLEX and all the other stuff is counter to this, also. But we figured on --

MEMBER ARMIJO: Yes, that's what I'm saying. So it's not really a factor.

MR. MONNINGER: Yes. But we thought it would be good to --

MEMBER SHACK: It occurs to people many times that somebody should mention this during the discussion.

MR. MONNINGER: The independence of barriers. The notion of a filter, we believe it would minimize the dependencies between the containment and the reactor coolant system. We believe the filter would provide a system that is independent of the, to a large extent, independent of what's going on in the integrated plant response.

MEMBER STETKAR: But for it to be effective, you still need to get water.

MR. MONNINGER: Yes, yes.

MEMBER STETKAR: So when you say integrated plant response, I think of ways to get water in, regardless of whether they're piped into the plant or there are fire trucks. So it's not divorced in that sense.

MR. MONNINGER: Yes. Because without the cooling systems, you're subject to liner melt-through, you're subject to containment over-temperature failure or over-pressure, well, containment over-temperature failure or liner melt-through.

Slide 24, we've labeled this consistency between reactor technologies. This could also potentially be a con. When you look at NUREG 1150 or some of the various risk assessments out there, when you look at the societal risk measures, there's a certain level of equivalence between the Bs and the Ps and all of that, and it's sort of a washout with the higher CDF versus a lower CDF, a stronger containment versus a weaker containment. If a filter is proposed or is required for the Mark I and Mark II containments, you could say that's an inconsistency. If they're all currently providing an equivalent level of safety, why are you now requiring a filter for the Mark Is and Mark IIs? So that argument could be made out there. The staff, our thought is we recognize that, but, given the high conditional containment failure probability for Mark Is or IIs and for defense-in-depth purposes, we believe it's the right thing to do.

External vents. Not only do they

potentially impact the reactor sight, but they also impact the local community. We believe a filtered vent would avoid the nuclear power plant contributing significantly to the impact, the other impact in the local community following external events.

The next slide, multi-unit events. Within our analysis, we assumed just one core damage event. We didn't assume multi-unit events. If you look at some of the studies, some of the results that have come out of Japan, they talk about the complications that occurred due to the failure of the containment failure, the reactor building's closure, with unit one impacting the response to units two and three. We believe that if there was a potential filter there and if the filter was successful, it would benefit the operation's response to the other non-impacted units.

CHAIR SCHULTZ: I'm just struggling with the word, with the choice of the phrase up on this slide and in the previous slide, and there may be others, where we call it a significant advantage. Of course, the likelihood comes into play if we describe an event that affects the local community and so forth, and then the vent would have a significant advantage. It presumes that the plant is in a particular condition, and it could have a significant advantage, we know, for certain sequences but there are many in which it could not have a significant advantage at all. So I just, I struggle with the use of the word in each of the qualitative evaluations.

MR. MONNINGER: And we'll go back and look at that to see how we could be more clear in our intent, given the low likelihood of the events.

CHAIR SCHULTZ: That's what strikes me, the low likelihood of the events. And in some cases, it will not provide an advantage. A release will occur in any case, whether you have the vent or not, the filter or not, as we saw at Fukushima.

MR. MONNINGER: And I guess the thought is you can have failures in the vent pathways, you could have failures associated with providing cooling to the core debris on the floor or you could be in other sequences, you know, bypass sequences or etcetera. But when you look at the entire spectrum of sequences, we believe a filtered vent would provide a benefit to a very high percentage of the accident sequences out there for Mark Is and Mark IIs. You know, given that the containment has a very high failure probability, you know, then you come in and what does the filter vent do to decrease that high conditional containment failure probability? So we believe it would be of benefit to a significant number of sequences, a very high percentage.

CHAIR SCHULTZ: Okay. I'll think about that and come back tomorrow.

MR. MONNINGER: Well, I think it's driven, you know, by the failure of water to the cavity floor. If you were to assume water goes to the floor, then all those sequences there, especially with the passive one, goes to --

MEMBER STETKAR: That's true. Or if it's there to begin with.

MR. MONNINGER: All right. So I'll turn over to --

MR. DENNIG: Yes, I'm about to get us back on schedule. Slides 27, 28, and 29, I cannot see anything that has not been spoken about here before at some extent and detail. And it's just a recapitulation of things that you'll find in the CPIP documents and all that stuff. So rather than waste your time on that, I'd like to just pick up at slide 30, if I could, please. And this, again, is a recapitulation, and it's not new to anybody. But the one thing that I did want to mention briefly was that, in response to the Generic Letter 89.16, which did discuss prolonged SBO and did discuss possible uses for severe accident mitigation, what that translated into what the plants did was not SBO capable. And the severe accident aspects were also not incorporated in the designs that resulted from the requests in the generic letter. So that's all I had to say on that.

I get to talk about foreign experience, which John has already said does not play much into our thinking. But --

MEMBER CORRADINI: Can I -- I thought your response to, if I heard that right, I thought your response mainly to John about performance-based was, maybe I misinterpreted, is that the fact the Swedes went through a performance-based thinking process and came to the conclusion this was essentially --

MR. DENNIG: Yes, I'm going to go through that. I'll go through that. Okay. Within the paper, you already read about the status of filtered vents and regulatory basis in other countries. We did speak with the folks that we met with about the downside of having an external engineered filtered venting system, and, before I forget them, the impacts of that and the possible unforeseen circumstances, if you will, were appreciated up-front and avoided by making the system independent of everything else. The FCVS does not, for power instruments, piping, there's no reliance on any other system. And that also allowed them to do -- the work to put the system in was done in two regular outages. The outages weren't extended. And most of that work is the tie-in to the penetration.

And in terms of the other downsides, things like external events and tornadoes and hurricanes and so on and so forth come up. And in those cases, they either incorporated what they knew at the time to be the most extreme circumstance that they wanted to deal with or they're revisiting that as a result of their stress tests. It's on a to-do list for some countries to go back and revisit earthquakes and floods and icing and the rest of those things. So they may have some additional things that they're going to do.

So the next slide, please.

MEMBER SKILLMAN: Bob, before you go, on that slide, the third bullet, how do they handle the source term that comes from removal of the cesium?

MR. DENNIG: In terms of outside the containment or --

MEMBER SKILLMAN: Okay. Here's this box. Maybe it's concrete, and maybe it's steel. And inside that box, a regular core, 17 billion curies on the fission product isotope curve, major, major fraction of cesium-134 and -137, the operators repair. And so there will be, eight or ten hours out, a huge amount of cesium, and it's potent. So what do they say about the source term? Where do you put this stuff?

MR. DENNIG: The external filters are installed in places that are already inaccessible or made inaccessible or, failing that, there are shield walls that are put up. Point Lepreau installed theirs up against containment and put seismic and shield wall on two sides and then on the top. So the source term is acknowledged. There are provisions for getting the stuff back from the filter back into the containment when you're done, when you're finished and when you want to get it back. There's usually a drain line, sometimes a pump to pump it back into the containment so that it doesn't stay out there. So it's out there for the necessary period. It's in a shielded or inaccessible location. Piping is routed such that it's not a hazard, and there are provisions for getting the source term back into the containment when you're finished using the filter.

MR. BETTLE: Yes, that pretty much covers it. Most of them have the capability of either gravity draining or hopping back in compartments with a shielded filter drain pumps.

MEMBER REMPE: In one of these prior meetings, we talked about changes to the operating procedures to accommodate these vents, and did we ever hear back the answer to what specific things we changed in the operating procedures?

MR. MONNINGER: From the foreign countries?

MEMBER REMPE: Yes.

MR. MONNINGER: Yes. And the Germans were in with Westinghouse, and we asked them that question and they said, well, we didn't, I guess -- so Westinghouse bought out -- anyway, they said when the various countries that they were representing either as vendors or because they lived in Germany or wherever, they said, well, we didn't model it just for the filters, we had a whole package of improvements that were done for the plant. So we asked them what was the change in risk for the filters, and we looked at everything that was required, so it was more of a, I guess, integrated type response that the European countries had. So the procedures would need to be revised, but they're were advised the procedures, not just for the filters but for all the other things that they require.

MEMBER STETKAR: So I think, actually, in timing, the filters were installed primarily in the late 80s into the 90s, if I recall, in most European countries. And the SAMGs, what you're talking about, Westinghouse was a leader over there, weren't developed until the early 2000s really. So, essentially, they already had something, you know, the hardware --

MEMBER REMPE: So has anyone stopped to think about what changes will have to be accommodated because of it and to avoid any adverse --

MEMBER STETKAR: That's why I asked the industry whether they had thought about that.

MEMBER REMPE: Has the staff?

MR. MONNINGER: Well, part of the order says, you know, you have to incorporate it into operating procedures, and the procedures were venting. The preferential first pathway we would hope would be the filter vent and then others. They are currently in the process of revising the SAMGs, and you would expect that if a filter was required they would incorporate the operation of the filter into the SAMGs, and the NRC will be involved in the transition between the SAMGs, the European --

MR. DENNIG: Are you thinking in terms of there is some way of operating this system that will make the accident worse that we haven't anticipated --

MEMBER REMPE: Well, one of the things to consider is adverse type of actions, opening it at a wrong time for example or something or another, and I just was wondering if you started to think about that yet or have thought about --

CHAIR SCHULTZ: The other piece of unintended consequences that operations involved or diverted in some fashion that's going to make the situation worse rather than better.

MR. MONNINGER: We asked the question, and it's always come back with they hadn't identified anyone. I mean, one of the issues that you do have with the boilers, of course, if you were to vent through the filter, through the option four or option two, is the loss of a non-condensable, and there are issues, potential issues with implosion of these containments. You do have vacuum breakers, but the vacuum breakers would not be sized to make up for this loss of non-condensables. If you go into the EOPs, currently there is a thing called the DWSIL, the dry well spray initiation limit. Fundamental within the calculation of that limit is the number of molds and non-condensables, and it assumes that, you know, you know the number of molds, so you don't draw a vacuum on it. And there's been one or two people who attended some of our public meetings that did raise this issue of negative containment factoring, but, other than that, I can't think of -- we have routinely asked the question. The only one we've heard about is the negative containment pressure. But you currently have that issue out there.

MR. DENNIG: Slide 32, please.

CHAIR SCHULTZ: Well, John, it's out there, but if you've got something that would suggest to an operator that, oh, we can go ahead and do it because we've got a filter, and so the propensity may be do it and perhaps at the wrong time and without proper attention.

MR. DENNIG: I guess we should think about that, but the issues that came up at Fukushima were the inability to vent was causing the problem and, certainly, you know, not venting at the wrong time. We should think about that. And like John said, we asked the question routinely, and the answer is that, well, we've got this, we developed our SAMGs, the SAMGs work, you know, the usual answer. And nobody has said we've got to be careful with one of the -- you know, one of the negative things of this or one of the things you've got to look out for that we haven't gotten.

MR. MONNINGER: A lot of it goes to the initiation of some type of active cooling system where you would suck out your steam very quickly, so there's limits in there on the sprays or there would be a potential limit in there on fan coolers or something like that. But if you were to vent and then shut it off, you know, just the decay heat within the containment should maintain that, but it would be more of a concern if you actively then went in and were to spray a high, high capacity spray and really take out your steam very quickly.

MR. DENNIG: Slide 32. I think you've seen this slide before. Nothing much new. The point I wanted to talk about was the third bullet. And the way this develops in other countries is that they go into the question of how can I make the containment stronger and, in particular, with regard to over-pressure and reduce the consequences of a release. And out of that comes three basic functions. One is flooding underneath the pedestal. The other is the ability to continue to put water into flood-up, and the filter containment venting system which can be used as feed and bleed with the system that puts in the water into the containment. That system is normally the spray system that's run off of a smaller pump. It's not used for decontamination. It's, again, used for this cooling function. But the three things work together. And in the case of the containment flooding and core debris coverage, they put in an independent system that has its own piping tubes. The only thing that they've used is the dry well sparger and the spray and ring in the containment, and it's an independent pipe that runs to a fire system or it can be hooked to a fire truck or it goes to a dedicated diesel-driven pump. So that's who they assure themselves that they have a reliable source of this debris management.

So they did a filter containment venting system, which opens passively and, in most cases, can operate for 24 hours before it needs any kind of attention. They always have a bypass with an active capability. They have also the ability to isolate the ruptured disk path if they want to keep the ruptured disk intact.

But in terms of, you know, overall, they view it as a severe accident management package for the containment function. And so that's where we get into, yes, everybody agrees that you have to have the water in there eventually if you're going to do anything, and that's how they approach it. So that's slide 32.

Slide 33. I don't see anything new to point out there. Slide 34. The Swedes started this, and they have a released performance goal, which is the 0.1 percent of cesium and iodine from a 1,800 megawatt thermal reactor period, and that's the source term. And you won't release more than 0.1 percent of that. That's the overall.

One of the side conditions is that you're not going to have a filtered vent that does any better than the containment does if you're not venting, if you don't need to vent. That was another consideration.

And then pretty much, as best we can tell, as best I can tell, that from that point in development of the technology, other countries have pretty much adopted the external filters on a DF basis. They specify a minimum decontamination factor for the vent path, and that's how they go at it. That's all I have to say on that.

MEMBER ARMIJO: And this is a decontamination factor that's principally focused on cesium?

MR. DENNIG: Cesium, iodine, and there are words, like in anything else, that would contribute to a long-term dose returning populations. But it boils down to cesium and iodine 131, I think is where it goes.

And next slide. This is just the -- we are interested in the Mark Is and the Mark IIs and the pressure suppression containments. That's what's in the NTTF report, and that's what the history tells us we should be interested in. And this just an illustration of the populations outside the U.S. for those containment designs. We have 23 Mark Is and 8 Mark IIs. Considering Mark I is Spain and the Mark III is also Spain, no FSDS decision -- Mark Is is India, and Mark IIs is Mexico, and that's pretty all I had to say on that slide, just to put that in perspective.

And I'm finished.

MR. BETTLE: Okay. My name is Jerry Bettle. I work in the Containment and Ventilation branch. I'm going to speak to a couple slides here on Enclosure 4, the slide 36, Mark I and II containment severe accident performance. The enclosure discusses the existing containments, spray systems, flooding, venting, as well as fr the existing containment configurations. With decontamination you can inspect from the dry well spray through the wet well and what the performance is with the external engineered filter systems.

Also, discuss the EPRI evaluation. In our comprehensive report, we provided a little critique there. And also talk about past containment vent actuation capability and early venting.

I guess I'm talking about early venting, and it's come up several times. People talk about it kind of like in two time frames. One, before we actually get to core damage to depressurization the containment, allow for a low-pressured pump injection for both putting water onto the floor, as well as into the vessel. But later, when you do start to drop level through the core and you get hydrogen production before you have a significant fission product inventory containment to get ahead of the game and vent out a lot of the non-condensable. The nitrogen and the early part of the hydrogen production. So I guess when people talk about early vent, it really covers kind of two situations.

At the plant's existing guidance and the emergency operation procedures severe accident management guides, and extreme damage mitigation guides prescribe multiple containment vent pathways and use of portable pumps for reactor and dry well injection. Focus is where it should be: on preventing core damage.

Also, in Enclosure 4, we talk about dry well sprays, how they perform for decontamination. The existing spray headers for the Mark Is and Mark IIs are designed for, as been discussed before, anywhere from 3,000 to 10,000 gallon per minute. The portable pumps, the B5B requirement was at least 300 gallons per minute. The EPRI study assumed a flow rate of 500 gallons per minute. Either of those, it's basically the low hundreds of GPM. You're really not going to have spray in the normal sense of sprays as far as the decontamination usefulness.

MEMBER ARMIJO: Do you agree with the EPRI conclusion that the spray part only improves the decontamination by a factor of two compared to just getting the water on the floor?

MR. BETTLE: It's possible. I mean that would be really hard to measure. I don't think there's been any testing to go with the particular configuration of that kind of spray flow. Just as an example there's one alternative source term evaluation that was done for Mark II. And although their spray headers were like 61 feet up from the floor, they're only giving credit for 8 feet of free fall for the droplets. They did scale down about 50 percent on the spray flow rate assuming that the spray at 50 percent flow would still be spray and still be affecting this. But they cut it down.

If you talk about droplets size, if you're just talking about garden hose type flow coming out of a number of nozzle heads, it's going to impact the surface and just be surface runoff pretty quickly. And if you've ever been a Mark I containment, that's pretty tight there. You can't go very many feet before you hit something hard.

So it's going to be very low and it's almost to the point I guess where we pretty much considered it negligible. Maybe it cools down the structures. You see a little bit of that are played out. You don't get revolatilization. It might have that kind of effect.

MEMBER ARMIJO: Unless you have the high flow rates you would --

MR. BETTLE: You're not going to get much to the contamination. They do have a flow in there. It does provide it. It gives a good distribution in contamination. It runs down to protect from the wall melt-through and in a sense it's distributed inside containment. At the flow rates, you do get 500 gallons per minute principal sub-cooling when it runs down into the suppression pool.

MEMBER ARMIJO: My question that I'm --

MR. BETTLE: I don't think it's the spray. I don't think that you would necessarily even count on decontamination too from the actual spray in the air, the droplets.

MEMBER ARMIJO: Not if it's just dribbling out.

MR. BETTLE: Yes.

MEMBER ARMIJO: Yes, I agree with that. But I'm just wondering. The systems there --

MR. BETTLE: Yes.

MEMBER ARMIJO: -- and in the reports or the briefings we had October 3rd I was taken by Marty Stutzke's bar charts for all these mod cases of filtered versus unfiltered venting through the suppression pool versus venting through the dry well. The only case that stood out as really a bad news was venting and unfiltered through the dry well.

MR. BETTLE: Yes.

MEMBER ARMIJO: And so it kind of pointed out the weakness in the system. So why wouldn't it be worthwhile to address how to solve that problem by either making the flow to the dry well sprays more reliable or a back-up system? It's just a matter of how you want to spend your money. Why wasn't that evaluated or studied?

MR. BETTLE: In terms of actually requiring enough flow to make the existing containment spray headers work as effective decontamination.

MEMBER ARMIJO: I don't know what it would cost.

MR. BETTLE: Thousands of gallons per --

MEMBER ARMIJO: I don't think anybody studied it. And as somebody said, "Well, we'll put in different nozzles to do this. We'll bring in the bigger pumps." How does that compare in the cost benefit with adding a filter?

MR. BETTLE: I don't think anybody has suggested bringing in the kind of pumps, the portable pumps. They kind of lose their portable connotation when you start getting several thousand gallons.

MR. DENNIG: Other places it wasn't a tradeoff. It was both. I mean it didn't evaluate that or the filtered vent. It was both. So I don't think that they broke it out in other countries.

At the time of the generic letter, the staff did talk about using spray versus the value of covering the core debris. And the opinion then was that the spray was not -- And again this was at the low flows -- anything to be considered vis-à-vis what you would get from eventually flooding and covering the core debris.

MEMBER STETKAR: Jerry, when you say feasible for portability, do you mean on a little red wagon or?

MR. BETTLE: Yes.

MEMBER STETKAR: No, I've been in power plants the size of a 3,000 gallon per minute centrifugal low pressure, not high pressure -- This is a low pressure pump -- would easily fit in this space in front of us here. Easily.

MR. BETTLE: Right.

MEMBER STETKAR: So that's pretty portable if I have a decent sized pickup truck I think.

MR. BETTLE: Yes, and in which case soon you'd be locked into making sure you had some motorized ability to push it around. It's something that three guys couldn't push very far around.

MEMBER STETKAR: Yes. I mean if you're thinking about literally something that portable you're absolutely right.

MR. BETTLE: Yes, when you get down to

that 300-400 gallon range that's the size a couple of guys could muscle around if you needed to.

MEMBER STETKAR: You're right. Yes. That's true.

MEMBER ARMIJO: No matter what we're talking about spending tens of millions of dollars and I'm just trying to find out is the addition of a filtered vent to optimum solution for every feet of the Mark I and Mark II or are there smarter ways or different ways that would be better by upgrading or improving or protecting existing systems that provide that decontamination function? And it looks like the suppression pool does a great job of decontamination and the dry well apparently doesn't.

CHAIR SCHULTZ: Put the slide up.

MR. MONNINGER: Okay.

CHAIR SCHULTZ: So much so that if the filtered vent were there it wouldn't provide much extra benefit.

MR. BETTLE: Let's jump ahead to this slide here. This comes out of Brookhaven.

MEMBER CORRADINI: Do you want to come up and use my chair, Sam?

MEMBER ARMIJO: No, I'll squint.

MR. BETTLE: If you have the ability to

read this. If you look at it, that's Brookhaven National Labs Technical Report. This is basically the general understanding of the effectiveness of the various existing containment decontamination system capabilities.

Up at the top, you have it when the core is exited the vessel. It's on the floor. That's why you have the shallow pool over the core debris. The bottom two are what you're getting when the core is still in the vessel. You can see there's a considerable amount of uncertainty as to what decontamination factor you'd get.

MR. DENNIG: And that spray assumes 10,000 gpm.

MR. BETTLE: That's normal spray flow, not the reduced flex style of spray flow. Most of those tend down towards defaulting down in the 10 to 100 range.

Now this didn't involve the EPRI study with vent cycling to try to maximize what you can get there or get into maintaining substantial sub-cooling in the pool for the pool decontamination factor.

You go back to slide eight just talking a little bit about what you get for decontamination in the pool. You start out with the relief coming through the safety relief valves into the T-quenchers down near the bottom of the pool and starts out cool. And everybody pretty much agrees you're going to get a pretty high decontamination factor.

The pool heats up. That will drop off a little bit. The core comes out of the vessel and hits the floor. Then flow from that is coming down all those great big down-coming pipes that are sized for the initial LOCA blowdown. So you're going to have a very mild discharge through those down-coming pipes.

And the bottom half of the suppression chamber is going to be more or less thermally isolated. And you're just heating up the top half and the decontamination factor is going to be very, very minimal at that point. And I think that's what you kinda see on that graph on page 40.

MEMBER ARMIJO: It's time-dependent or it's temperature-dependent.

MR. BETTLE: Yes. As you progress to the accident. You know, when you get down there. A pool near saturation is not giving you a whole lot as far as decontamination and spray especially at very, very low flow rate sprays. It's not giving you very much. Now this is pretty much the accepted, expected capabilities as far as for the system.

Slide 41. As was discussed in the previous presentation, EPRI for the comprehensive study pretty much a computer modeling feasibility study. If I did this, if I did that, as far as what the inputs are. What kind of a decontamination factor could I get out of the containment of the containment systems as they work?

The employable portable pump, the melt core analysis that the Office of Reactor Research did assumed the 300 gallon per minute because that's the required minimum capacity. And the EPRI study assumed 500 gallons per minute. That does provide much more than you need for decay heat removal.

So it maintains quite a bit of suppression pool sub-cooling. Maintains a reasonably good decontamination capability there.

They also in their strategy maintain containment pressure elevated. I say elevated 40 to 60 pounds. That's above the -- right at the containment design pressure typically.

And they have to open the vent at 60 and close it at 40 and have to maintain that pretty rigidly to achieve a DF. Otherwise, they roll back down towards the values you see on the chart on page 40.

This places a lot of reliance on instrumentation for containment pressure, containment water level, suppression chamber water level and in the operator actions. There was some mention that, yes, you could put in some sort of automated relief valve or automate the control of these vent valves to open and close them precisely on schedule.

However, you also have to be maintaining an accurate indication of what the containment pressure and level are to achieve it. So you're utilizing the system. But you're kind of walking a little bit of a tightrope in that you get off that management schedule for the containment. Then your decontamination factors will roll back down considerably. So, as far as its feasibility, at this point, we don't see that it necessarily has a high likelihood of a successful implementation.

And that comes to the --

MEMBER STETKAR: Jerry.

MR. BETTLE: Yes.

MEMBER STETKAR: Come back to the question though how do the European severe accident management guidelines address that issue. Do they simply open it and keep it depressurized or do they cycle it and keep it --

MR. BETTLE: For the most part, they just open it and leave it open.

MEMBER STETKAR: They just leave it open.

MR. BETTLE: Yes. I mean they have the capability of closing it if for some reason they wanted to close.

MEMBER STETKAR: They don't use it.

MR. BETTLE: And obviously when they regain power in other design systems, they'll close it up and start cooling containment otherwise.

MEMBER STETKAR: Okay. Thanks.

MR. BETTLE: And there are a couple other things in going with that when you open it and leave it open. If you start out with inerted containment, you're constantly pushing out on this line. If you go into a sequential cycling a vent valve and you have 100-150 feet, maybe plus, of this piping, you close it. It's going to have a mixture of steam of hydrogen in there and the system is going start condensing. You're going to wind up with a flammable explosive mixture being recreated repeatedly in this line.

MR. MONNINGER: I think another question that comes up is the end state if you were to have an accident. There was a lot of interest especially in Fukushima for if there was a safe shutdown or whatever.

But what is the end state that you want? How long would you be relying upon the containment vent cycle? The analysis may be an artifact. They keep it at 72 hours. What kind of interest or pressure would there be put in that first day, that first three days, that first week, to take away that challenge to the containment?

It is over containment design pressures, the temperatures, your containment penetrations are leaking, etc. Is it a long-term success fact?

MR. BETTLE: The other thing of maintaining the pressure high is that especially in a Mark I you know you have a heat source in there. You're going to have some residual in the reactor vessel putting flow in through spray headers. They're down usually at the transition to the spherical section. You're not really providing that much cooling to the upper head. So any penetrations there that would be susceptible to heat are probably getting well above their design temperatures and may be going into leak excessively at, let's say, design pressure.

MR. MONNINGER: The next enclosure to the draft Commission papers, Enclosure 5, we have it divided into Enclosure 5A, B and C for the MELCOR, MACCS and PRA suctions. This was worked on by the NRC's Office of Nuclear Regulatory Research. They were integral to the entire project, not only the work with ME's enclosures, but the qualitative analysis, the work throughout the Commission paper.

MELCOR, we had a half day session on that in September and then an additional discussion in early October. And one of the interests from the ACRS was a copy of the MELCOR report which we have provided.

This is just the summary of the approach. We used the SOARCA modeling, the accident sequence as we looked at the long-term Station Blackout.

We looked at various mitigation actions whether it's providing cavity flooding through the core spray system or the dry well spray system. And we also did a series of sensitivity analysis. This work was done by Sub Basu who is here in conjunction with Sandia National Laboratory.

One thing I would like to mention is this notion of cavity flooding. It's discussed within the paper and the staff's current view or the current position that we documented in the paper is it's a current requirement.

If you look at 50.54(hh), it talks about the need for mitigation measures post 9/11 and the NRC has a reg guide out there and that reg guide then endorses the NEI document. That NEI document discussed the need to provide cavity to the dry well floor for core debris cooling.

MEMBER SHACK: But doesn't it allow it to go to the pressure vessel also? It's an or, isn't it?

MR. MONNINGER: Yes. It assumes if you melt the core comes at the bottom of the vessel --

MR. DENNIG: If you melt through it, it will break through.

MR. MONNINGER: But there were some statements whether that is viewed to be a current requirement or not. Within our reg analysis, we have taken credit for that being a current requirement. A statement was made that plants would have to look at that and have to do that. The staff at least on the team here used that as being a current requirement. So it either is or it isn't.

And for one case if we go back and we say that it is determined that it isn't, we would then add that also within the proposed order. So it is either currently required by 50.54(hh) or if it isn't currently required you would see that within the order. I just wanted to clarify that.

MEMBER REMPE: John, I know we asked for this report and the version that we got on the 26th of October is a mark-up. So I realize it's a draft. And maybe these things have already been fixed. But I appreciated the fact that the staff has gone through and tried to explain some things that are counter intuitive, the calculation results. But I did just a quick scan and there are some typos in there still with respect to some figures and having numbers mislabeled.

MR. MONNINGER: Okay.

MEMBER REMPE: But also I would encourage that someone go through and think a little bit more about non-intuitive results.

For example, Case 2 and Case 6 shouldn't have any differences in results presented until the vessel fails because we're talking about core spray and yet I did see some differences. So some things like that I think before this is final I hope will be attended to. But then maybe they've already been fixed. I know you guys are all fishing as hard as you can.

MR. MONNINGER: No, that's a good comment and we'll definitely go back in it.

The next slide, slide 43, it's been

mentioned several times by the industry and NRC staff that you need to water on dry well floor to provide liner melt-through. That was one of the observations coming out of the Containment Performance Improvement Program in the `80s, the Theofanos work at University of California Santa Barbara in the `90s, etc.

So it does various things. It prevents the liner melt-through and would also scrub fission products. The venting whether it's option 2, 3, or 4 would prevent overpressurization failure and that you do need a combination of both for success.

In Enclosure 5b, we discussed that at the October 34rd meeting. And that's the MACCS calculation. This summarizes the various outputs that we use from the MACCS codes. These are the typical outputs that are calculated and we use them within our regulatory analysis.

MEMBER STETKAR: And you did vary the economic costs associated with those outputs over ranges.

MR. MONNINGER: The economic costs?

MEMBER STETKAR: That's my question about what did you do on that vertical axis. In your plot, it shows the break even.

MR. MONNINGER: Yes. So go back to --

MS. GHOSH: I think it talks about --

CHAIR SCHULTZ: Go ahead and identify yourself, Tina, please. Thank you.

MS. GHOSH: This is Tina Ghosh from the Office of Research. I think you're talking about Marty Stutzke's analysis. Is that right? You're looking at the -- I see on your computers. Are you looking at the event tree that he's --

MEMBER STETKAR: No, I'm looking at -- No, the event tree don't look at my computer.

MS. GHOSH: Okay.

MEMBER STETKAR: I'm looking at my computer. You don't have to look at my computer. Don't presuppose what I'm asking.

MS. GHOSH: I apologize. Let me back up here.

MEMBER STETKAR: No. It's Marty -- The event tree that I'm looking at just sorts out the logical combinations of things. But within that logic structure that analysis was done let's say to investigate uncertainty on what I'll call the horizontal scale on this plot of varying core damage frequency by a factor of 10 higher from the nominal 2 X 10^{-5}. And that showed that you barely made it into the cost beneficial range at the costs associated with the nominal MACCS 2 analysis.

My question is I thought that I read that an uncertainty analysis or whatever you want to call it, sensitivity analysis, was done to vary the costs which would be fix someplace on the horizontal scale and vary it vertically. And I was curious if that was done. I asked you before. What range was associated or was the basis for that variation? What was it not done?

MS. GHOSH: As far as the economic costs that MACCS calculates, those are deterministically calculated based on the scenarios that we ran. So, for example, in the enclosure we talk about the eight cases that we ran with the filtered and unfiltered venting or no venting for some of the cases. For each of those cases we have a deterministic economic cost calculated by MACCS which is actually the average of the weather child (phonetic).

MEMBER STETKAR: I understand that.

MS. GHOSH: Yes. And then Marty on top of that added an uncertainty -- Well, I think John is going to get to that in the next enclosure. Marty tried to look at holistically combining the uncertainties across all the different pieces of the analysis and he added in an error factor to the MACCS outputs. So maybe that's what you're talking about.

MEMBER STETKAR: That's what I'm asking about.

MS. GHOSH: Yes.

MEMBER STETKAR: That's what I'm characterizing in this simple sense an uncertainty on the vertical axis here.

MS. GHOSH: Right.

MEMBER STETKAR: I know exactly what he did in terms of addressing uncertainties on the horizontal axis.

MS. GHOSH: So he did that post of the MACCS output.

MEMBER STETKAR: Okay.

MS. GHOSH: So MACCS gave a deterministic number. And then he added an uncertainty factor on top of that.

MEMBER STETKAR: Okay

MEMBER SHACK: But you did the cost for a single economic cost and basically a single site.

MS. GHOSH: That's right.

MEMBER SHACK: A fixed cost, a fixed population.

MS. GHOSH: That's right. It's a deterministic calculation based on the site characteristics. We used Peach Bottom.

MEMBER SHACK: Peach Bottom, right.

MEMBER STETKAR: She punted it back to you, John.

MR. MONNINGER: I know. And the table's not in here. And this is the version --

MEMBER STETKAR: No, it's not.

MR. MONNINGER: -- that you guys have also. And I do recall --

MEMBER STETKAR: There are words in there. I didn't do the word search. There are words to say and Tina just said there's an impression that that was done.

MR. MONNINGER: So for the various parameters whether it was CDF or whether it was operator response what he had was best estimate. And then they assigned a distribution, etc. I don't recall --

MEMBER STETKAR: But all that that does is change the split fractions if you call it that --

MR. MONNINGER: Right.

MEMBER STETKAR: -- for the different sequence frequencies in this event tree that I am now looking at.

MR. MONNINGER: And I don't recall him

assigning anything like that to the economic consequences.

MEMBER STETKAR: Okay.

MR. MONNINGER: We can't get back.

MEMBER STETKAR: Yes, because I thought I read the words in there somewhere that that was done. And it if wasn't then I misread the words someplace.

MR. MONNINGER: I mean at one time I think the base case we had a table in there comparing the base case offsite costs versus other hurricanes out there.

CHAIR SCHULTZ: Could you bring that back tomorrow, John? So we can see if there are any additional information. Because I don't think we have that detail in what we were provided in 5B.

MR. MONNINGER: Okay. We were on slide 44. These are the outputs that Tina talked about and we'll come back and we'll address whether there was uncertainty analysis done that included the economic costs. And these are the insights or results from the calculations. Essentially there was no prompt fatality risk calculated.

The level of exposure was too low to incur. So therefore the latent cancer fatality risk is one of the metrics out there of interest. In addition, we looked at land contamination being the shine from cesium-137. And there was a lot of discussion within the past meeting and actually within the paper of the various correlations between the decontamination factor and the help effects or economic consequences where land contamination being super-linear or sub-linear. And that's discussed within the report.

Slide 46 summarizes the PRA work that was done by Amarti. Condition contamination failure probability, the NRC, our SPAR models basically have the limited level 2 that stop at LERF. They don't look at the pool conditional contamination probability.

So we went back to the IPE reports and also we looked at the license amendment supplementals submitted by industry for the integrated leak break test. And generally that information shows high conditional containment failure probabilities which is still reflective of NUREG-1150 somewhere in the 0.7, 0.8, 0.9 order.

We also looked at insights from SAMA analysis and how the SAMA analysis had or had not evaluated filtered vents. As was mentioned earlier today, all the past NRC analysis for filtered vents have historically shown them to be not cost beneficial. And that also comes out of the results from the SAMA analysis.

Marty discusses his technical approach results in uncertainty analysis which we'll get additional information for you.

MS. GHOSH: John, this is Tina Ghosh again from the Office of Research. I would just point out there's a couple of tables in the Enclosure 5c that explain what Marty did with respect to the uncertainty for the cost consequences. Then the table -- I might have a slightly older version of the enclosures but 100 percent sure of the table number. But in the version I have there's a Table 12 called "Uncertainty Distributions" where he explains for all the consequence metrics what he did.

And then there is a figure for offsite cost risk which shows essentially the error bars, the point estimate mean, the 5th-95th given what he assigned in the table for the uncertainty distribution.

MEMBER STETKAR: Just to clarify things, Table 12 are uncertainty distributions that primarily except for the last line in it affect the split fractions in terms of sequence frequencies.

There is a line in my version of Table 12 that says "Consequences" under "Mean Value." It says, "Per Tables X-7 and X-8." I couldn't find those. And it's a log normal with an error factor of 10.

But I don't know what that meant. And then, yes, indeed you can see uncertainty bars in the final figures with things in them. But it wasn't -- I looked. I couldn't really find those. I'm not sure what those tables X-7 and X-8 are, John.

MR. MONNINGER: We'll have to get that information on that.

MEMBER STETKAR: Thank you.

And then as Tina mentioned, the plots at the end of Marty's work, it summarizes. We look at the base case going to Option 2 or Option 3 or Option 4. And we look at the change in the person dose and the change in the offsite cost. And we quantify all those and convert that into a dollar value. And you look at the benefits then for your proposed modification.

MEMBER STETKAR: John, one quick and I don't want to take up too much time because I know we're getting tight on time here. So rather than going through specific examples, as I went through the whole PRA section and looked at the numbers, I came away with kind of two conclusions. And that is that in some cases it seems that the model that was used may have selected so-called conservative values -- It might be human error probabilities. Might be equipment reliabilities -- that because of the values that were used effectively showed less numerical benefit to event or event with a filter than if perhaps more realistic or less conservative values.

And now I'm not talking necessarily about the uncertainty analysis. I'm talking about sliding that uncertainty range linearly along a scale of conservativeness if you want to call it that. That doesn't particularly affect your overall conclusions in the SECY paper because you're making the qualitative arguments.

The other part and I mentioned this earlier is there is I believe probably an unintended but there is a bias that tends to point toward a passively activated filter vent versus a manually activated vent.

And there are couple of examples that if we had more time I'd kind of walk you through them. But they're a little bit convoluted. It's I think another sense where perhaps conservative values for the purposes of SPAR models for one purpose might not necessarily give you the appropriate perspective from this type of application.

I mention the one in terms of coupling, saying, that given the fact the operators successfully opened the vent. Why are they not very good about lining up the flooding capability. And there's at least one other or two others that sort of work that way.

MR. MONNINGER: Yes.

MEMBER STETKAR: There are two. That doesn't affect the conclusions of the SECY paper because right now the SECY paper doesn't say make it passive. Make it active. Do not make it active. So not seeing how the orders are going to come down, it could affect that.

MR. MONNINGER: At risk, so my thought though is if you looked at the failure we assigned of 0.3 for the manual venting versus 0.001 for passive that's significantly a higher reliability for the passive.

MEMBER STETKAR: It is.

MR. MONNINGER: But then when you looked at the probability of a venting it only goes down by a factor -- by 20 percent. So I would have thought to me it undersells the value as opposed to oversells the passive venting.

MEMBER STETKAR: It undersells --

MR. MONNINGER: Because it shows that there's not much of a difference in the breakdown of the containment failure mode. So its venting is 47 percent for manual. The containment release is through a filtered vent is 47 percent if it's manual. And it's only 67 percent if it's passive on Table 9.

So you only get an increase in 20 percent for the venting --

MEMBER STETKAR: In those absolute senses, you're right.

MR. MONNINGER: Yes.

MEMBER STETKAR: There's not a big absolute difference.

MR. MONNINGER: Right. And the reason you get that is because the stuff still goes to liner melt-through of 28 percent. And that's driven by the 0.3.

MEMBER STETKAR: That's driven by the 0.3 of not getting the water in.

MR. MONNINGER: Right.

MEMBER STETKAR: Which might be close to zero. Well, not zero because the hardware.

MR. MONNINGER: And it would show a

significantly greater benefit for venting and passive venting.

MEMBER STETKAR: It would show a greater benefit for venting. It might show a greater benefit for manual -- less of a difference. Given the fact that the difference for passive versus manual in an absolute sense is not very large, they might not be even that small a difference if you want to think of it that way. If you looked at manual with a conditional high probability of getting the water in limited by whatever number you stuck in there for the hardware.

MR. MONNINGER: And we can get back to you tomorrow morning on this.

MEMBER STETKAR: As I said, in terms of the SECY paper itself, it doesn't affect the conclusions.

MR. MONNINGER: Right.

MEMBER STETKAR: You know, your recommendation within the context of the SECY paper. But the follow-on in terms of emphasis on manual versus passive systems, actively managed systems rather than passive systems, it could have a secondary effect.

MR. MONNINGER: Whereas we could have

tried to do some of these things more realistic or best estimate. We tried to take out any type of ammunition that could be used against the staff for stretching the case for it.

MEMBER STETKAR: You know, I originally thought of that.

MR. MONNINGER: Yes. We accepted that it's not cost beneficial. We could move it up but we knew it would never cross the threshold.

MEMBER STETKAR: Right.

MR. MONNINGER: So as opposed to arguments back and forth just say "This is what it is. We believe our qualitative arguments are significantly strong."

MEMBER STETKAR: And in a sense, numerically I agree with you. But I think that the net effect of the numerical part of the PRA suppresses the benefit of the vent and the filter.

CHAIR SCHULTZ: But it wouldn't drive the conclusion.

MEMBER STETKAR: It wouldn't drive -- I don't think it could make the number.

CHAIR SCHULTZ: Right.

MEMBER STETKAR: I don't think you could cook the numbers if you will in a way that would drive you at least in terms of the frequency of the event scenarios. Now the uncertainty -- You know, the other part of the problem that I raised earlier, the uncertainties, where the mean value of the cost, the economic consequences, and the assessment of the uncertainties around that, could make a difference.

MR. MONNINGER: I think if you look at the SAMDAs when they do the simplified analysis to eliminate all risk it's maybe $3 million or $4 million or so that the typical plant can spend to come up with the perfect plant to eliminate all risk.

MEMBER STETKAR: Even that, you don't make it.

MR. MONNINGER: Yes.

Slide 48, Stakeholder Interactions, we've had significant public meetings, a very good input from the nuclear industry, public interest groups, in person and via phone. We've also had written input that the staff has considered within its assessment.

CHAIR SCHULTZ: John, I know you've got some more slides to present including some discussion of ACRS comments and give and take there. I think given our schedule on the meeting, I'd like to pause here for the opportunity for public comment. And then come back to your presentation.

And in that regard as I mentioned at the beginning, we did have a request for time for oral statements from Mr. Paul Gunter. And I wanted to provide that opportunity first. Then we will have opportunity for other members of the public who would like to make comment.

MR. GUNTER: Paul Gunter with Beyond Nuclear. And I'm going to pass.

CHAIR SCHULTZ: Thank you, Paul.

Are there other members of the public in the meeting who would like to make comment in the meeting room? And while we think of that, Antonio, is the line open?

MR. DIAS: It should be open.

CHAIR SCHULTZ: Check on that, please.

Anyone else here present that would like to make comments?

(Off the record comments.)

I'd like to check and see that the line is open.

PARTICIPANT: I'm here. Can you hear me?

CHAIR SCHULTZ: Thank you. We can hear.

PARTICIPANT: Okay.

CHAIR SCHULTZ: And so knowing that the line is open, I'd like to ask anyone on the line is they would like to make a comment. Please introduce yourself and make a comment for the benefit of the meeting.

(No verbal response.)

I hear no volunteers for comment. And hearing none I'll close the public comment section of the meeting. He's had an opportunity certainly.

And so therefore, John, we will return back to your presentation. Thank you very much.

MR. MONNINGER: So it was a very good, dynamic stakeholder engagement, a lot of interested parties out there.

Slide 49, Enclosure 7, the draft orders which the ACRS does not have a copy of. Some of the considerations is the proposed implementation date. The current order out there requires industry to provide an integrated plan by February 2013 and then full implementation of the reliable hard vent by EA-12-050 by two refueling outages or December 31, 2016. So we are currently looking at assessing that implementation date. If we were to go with option B or option 2, the sealed accident capable vent, is that still a realistic schedule? If we were recommend option 3, a filter vent, or if we were to recommend option 4, the performance-based approach with option

2 tagged in there.

Some of the things we're looking at is the implementation date. We would propose similar to the other orders to provide high level technical requirements. Followed that up with a series of meetings with stakeholders to develop a guidance document that would be endorsed.

CHAIR SCHULTZ: From what you just described, John, you indicated that you were going to provide some element of schedule expectation for each of the options or focusing on two and three?

MR. MONNINGER: We have some --

MR. DENNIG: We have draft orders for all of them.

MR. MONNINGER: Yes, we would just have draft orders for two and three. And then four would be a potential rulemaking. And what we talk in there is that rulemakings, especially performance-based, the time frames are typically pretty significant. So we think it would definitely have an impact on the 2016 date for any rulemaking for the performance-based approach.

The filter vent was tied to the reliable hard vent. Both of these issues are Tier 1 issues which the Commission has established an expectation of completion by December 31, 2016.

With that said, we do recognize that any potential order, be it recommendation two or three, would be one year after the first order. Does it make -- Is there logic there to keep the current schedule or is there logic there to provide some amount of additional time?

CHAIR SCHULTZ: Thank you.

MR. MONNINGER: The bigger factor of course would be the filter vent. It could be a significant plant modification.

Slide 50, some previous ACRS questions that we had. There were questions about the particle removal capabilities be it for the filter vents or for suppression pools or sprays. The particle sizes, there's a distribution of sizes. There is I guess a zone in there which historically researchers have identified difficulties in removing particles of that particular size. More recently, the presentations and the discussions that we've have with the various vendors out there of filters, they discuss this issue. And they discuss testing for these difficult-to-capture particles.

We believe it's a known issue out there. It's not just for the filters. It's for the suppression pool. It's for the sprays, etc. And they are explicitly trying to address this issue.

MR. DENNIG: Yes, I think the way I understand it is if you have a really good performance from a pool and you've alter the spectrum of particles, what gets to a filter is then a distribution at the lower end and much more difficult to move. So the size-specific efficiency of filter you would expect to not be so good.

It's premised on the pool doing something in the first place to change that spectrum. But in the discussions we've had, the efficiency for the sub-micron particles are not 100 percent or 99.9, but they're high. They're represented as being high in that there are test results that demonstrate that.

And as John said, the rationale for pursuing Venturi scrubbing was for sub-micron particle, for efficient removal of sub-micron particles.

And there is this three levels within the wet scrubbing system. There's this larger portion of it with the Venturi and then there's the cool portion of it and then there's the metallic fiber portion of it. And those are given different DFs for different size particles. I don't know how that adds up.

CHAIR SCHULTZ: It seems to me that that adds up to a pretty complication specification is one were to sit down and write it for a number of plants that are designed differently and have different capabilities and essentially with regard to severe accident mitigation. But that's just a quick view.

MR. DENNIG: I think we were to concentrate --

CHAIR SCHULTZ: But it sounds very complicated.

MR. DENNIG: -- on cesium and iodine that gives us an idea of the particle sizes.

CHAIR SCHULTZ: Yes.

MR. DENNIG: And we can look at testing for that distribution of particle size to see if there is a significant roll-off in the DF. Usually, cesium distribution is, the average is 1.0 to 1.5 microns. And it's a log linear distribution that's input. And we know about this issue. But we believe it's been addressed and we would follow up to look at the testing to make sure that that is the case.

CHAIR SCHULTZ: Okay. I guess the other way I could phrase my feeling based on what I heard you say is that you just described a research program and that research program might take a long time to do. And it didn't match up with John's schedule.

MR. DENNIG: What I'm saying is that I think the research program has been completed.

CHAIR SCHULTZ: Okay.

MR. DENNIG: Basically over the last 30 years. And it's a matter of auditing that material to make sure that the representations and the statistics and the slides and the discussions we've had are verifiable in the test data.

CHAIR SCHULTZ: I appreciate that. Thank you.

MR. MONNINGER: Slide 51. The results. A question that was raised regarding the impact of noble gases on site operations. This issue was raised in connection with the staff's statements that there may be a higher level of confidence or I won't say a higher frequency of venting. But if the operators believe that they have a good system they may be more likely to use it.

If that then is the case, what is the impact on site operations, personnel within a control room, etc. from noble gases and, in particularly, heavier-than-air noble gases?

We engaged our Radiological Protection branch and basically said, "It's a big function of the weather." Traditionally, where these releases were to occur at the top of the stack, the wind velocities, the stabilities, etc., a typical release would have little to no impact from typical meteorological conditions.

Where it could potentially have an impact would be for the unstable, the inversion I guess, of weather, wherein the release would be a push down onto the site. Given the control room, suite of buildings, etc., the staff thought that there would be shielding available to the operators and a rough level assessment we didn't believe that it would exceed the regulatory dose limits for an exposure.

MR. DENNIG: But, John, so the worst-case weather conditions, he didn't expect that they would exceed the 25 in a lifetime.

MR. MONNINGER: Lifetime.

MR. DENNIG: And that was just thinking based on some rough calculations and his experience.

MR. MONNINGER: Can I go back to the small particle thing? Another way to think about it is if you have a vent on a wet well and you get zip. You get nothing from the wet well. So the spectrum going to the filter is unchanged from the release spectrum.

And I don't think there's any argument

about the filter doing 1,000 or greater DF on that spectrum.

If you put that in series with a wet well and argue that you've gotten a really good scrub on larger sized particles from the wet well so that what goes to the external filter has gone through a window so to speak. And it's a lot smaller or highly penetrating than you would expect. You can argue that you're going to get less than 1,000. If you think the thing can be 2,000, you're going to get less than 2,000.

The way it was modeled, the way we modeled it, was to give it a 10. So we haven't represented the ability of the external filter in a way that is inconsistent with the idea that sub-micron particles are harder to stop.

CHAIR SCHULTZ: That's correct. I understand that. Thank you.

MR. MONNINGER: The last slide.

MEMBER RYAN: Jerry, just one quick question out of curiosity. Did you do any re-entrainment from filters over a long use period particularly employing the real small particles?

MR. BETTLE: The designs that have that metal fiber filters on the top.

MR. DENNIG: Do you mean within the filter itself?

MEMBER RYAN: And eventually out the back end, yes.

MR. BETTLE: They either have a droplet separator or a filter metal fiber at the top to catch anything that bubble up from very small droplets to come up. They're supposed to capture essentially everything like just dry steam or gas coming up.

MEMBER RYAN: Thank you.

MR. MONNINGER: In conclusion, the staff believes that the combination of quantitative and qualitative factors best supports the installation of filter venting for Mark I and Mark II. That's option 3. Preponderance of that evidence or preponderance of the staff's argument is the qualitative defense-in-depth argument and the notion to have a system that is independent of the existing weaknesses within the containment design.

The other thing I'll mention is if you do look at the guidance within NUREG-0058, it talks about the need to consider qualitative factors and in particular when addressing containment performance or when addressing issues associated with late containment failure.

So what the staff did do here, any consideration of the qualitative is consistent with our finding. It's not --

MEMBER RYAN: You ought to take that off your microphone.

MR. MONNINGER: Yes. It's not done frequently, but it is within our guidance that is out there. And that concludes the staff's presentation.

CHAIR SCHULTZ: First, any general questions over the last portion here that someone has not had an opportunity to ask?

MEMBER ARMIJO: Just a comment on some of these enclosures. I think enclosure 5C and I think B. There are some very nice colored pie charts, but there is no scales. You kind of have to decipher what Marty's -- I believe those are Marty's reports. I'm not sure.

MR. MONNINGER: We can look at that.

MEMBER ARMIJO: Maybe you have some with scales and numbers.

MR. MONNINGER: We can look at that this evening.

MEMBER ARMIJO: Yes. That's what we got in the packet.

CHAIR SCHULTZ: With that then, I'd like

to go around the room and ask the members for particular comments they might have with regard to the presentations we've heard this afternoon, knowing that we will have an opportunity to do this again in short form tomorrow.

But, Dick, any comments you'd like to present?

MEMBER SKILLMAN: I thank you for the thoroughness of this presentation. I would like to express a concern. And the concern is that the staff has concluded that a hardware fix is the right fix. And if I go back to my history after the TMI2 accident at TMI2 with the NRC we spent probably one to two years battling over what should be the quality level, the fabrication requirements, the welding requirements, the NED requirements.

When you choose to write an order, please ensure that you've packaged the requirements with that order so industry is not left to fight among itself or with you over what you really intend. For instance, you might require this to be Appendix B in containment quality which makes it at least quality group C, probably B. Or you might say robust industrial standards with QA requirements only for the containment portion that's not isolated that's within the containment boundary.

But the specificity of the hardware accompanying order will at least give industry a target to begin with. Absent that, I believe that this will go into freefall.

Mr. Chairman, thank you.

CHAIR SCHULTZ: Sam?

MEMBER ARMIJO: No, I'll just comment after.

CHAIR SCHULTZ: John.

MEMBER STETKAR: Nothing. Thanks for a very good, thorough presentation. Nothing else.

MEMBER RYAN: I second John's comment. Thank you.

MEMBER SHACK: No comment.

CHAIR SCHULTZ: Charlie.

MEMBER BROWN: No comment.

MEMBER REMPE: No comment. Very good.

MEMBER CORRADINI: Not yet.

CHAIR SCHULTZ: John will have an opportunity to sleep on this one.

MEMBER ARMIJO: Come back tomorrow.

CHAIR SCHULTZ: And we did have some bring-backs associated with the discussion today.

MR. MONNINGER: Yes.

CHAIR SCHULTZ: Because of the weather we've had a few members unable to be here this afternoon who I know wanted to be here and they will be here tomorrow. I would suggest that knowing the time is shorter that you go through the presentation and focus on those areas that you feel are most important to the case that you've presented today.

I think that our discussion ought to focus on the qualitative arguments knowing that the quantitative analysis has been done, but is not the key feature upon which you based your recommendation. So I would like to see that come through again and it is in those areas that we've raised some questions for responses from you tomorrow.

With that, I also want to thank each of you for the discussions that you've presented today. In spite of the shortness of time you've had to prepare it, given the weather, it's been quite a very well organized and insightful presentation that you've made. And I appreciate that very much. On behalf of the Committee, I thank you.

And we'll see you again tomorrow. I would hope that you would all be here again tomorrow because I think you've all contributed to the discussion. Thank you very much.

MR. MONNINGER: Thank you.

CHAIR SCHULTZ: Off the record.

(Whereupon, at 5:15 p.m., the above entitled matter was concluded.)

Containment Filtering –Industry Perspective–

Fukushima Subcommittee
Advisory Committee on Reactor Safeguards
October 31, 2012

Industry Position

- BWR Mark I and II should have capability to use various containment filtering strategies to mitigate releases and land contamination during core damage events.
- Performance-based strategies founded on scientific and factual analysis
- Comprehensive approach that ensures containment and filtering for extreme core damage events.

Context

- Beyond design basis events
- Extremely low chance of needing filtering
- Reliable harden vents provide heat removal path to prevent containment overpressure
- Filtering strategies reduce the impact of potential containment releases in the event of core damage
- Previous NRC evaluations of containment filters
- Use of qualitative factors and extreme scenarios

Ensuring Very Low-Frequency of Release

- Protecting facilities from extreme natural phenomena
- Preventing fuel damage through design-basis measures
- Preventing fuel damage through beyond-design-basis measures
- Arresting the accident progression
- Minimizing radionuclide release by retaining in containment

NRC Staff Regulatory Analysis Demonstrates Addition of Filters is not Justifiable

Important Insights from EPRI and NRC Evaluations

- All filtering strategies (with or without external filters) rely on operator action to cool the core debris to be effective
  - Filtering strategies and external filters require same conditions to be effective
- Maintain containment integrity
  - Active debris cooling
  - Containment vent cycling
- Water injection into containment filters potential releases
  - Water spray and flood filter airborne aerosols
  - Cycling of vent maximizes aerosol capture and manages hydrogen
- Decontamination factor greater than 1000 achievable
  - Common international requirement

Industry Recommendation and Impact on Plants

- Individual plant evaluations determine strategy
  - Performance basis required
- Plant modifications may be needed
  - Ensure severe event spray and/or flood
  - Wetwell and drywell vents required
  - FLEX capability enhanced
  - SAMGs enhanced
  - Mark II pedestal drains require protection
  - Possible additional filters needed on plant specific basis (more research needed)
- Encourage innovation; vendor response

Industry Next Steps

- Perform a table top pilot to:
  - Investigate practicalities of plant-specific implementation of filtering strategies:
    - Required design changes
    - Procedural/SAMG enhancements
    - Containment vent filter considerations
  - Develop example plant-specific performance-based assessment of filtering strategies
    - Overall containment system DF for representative plant-specific scenarios

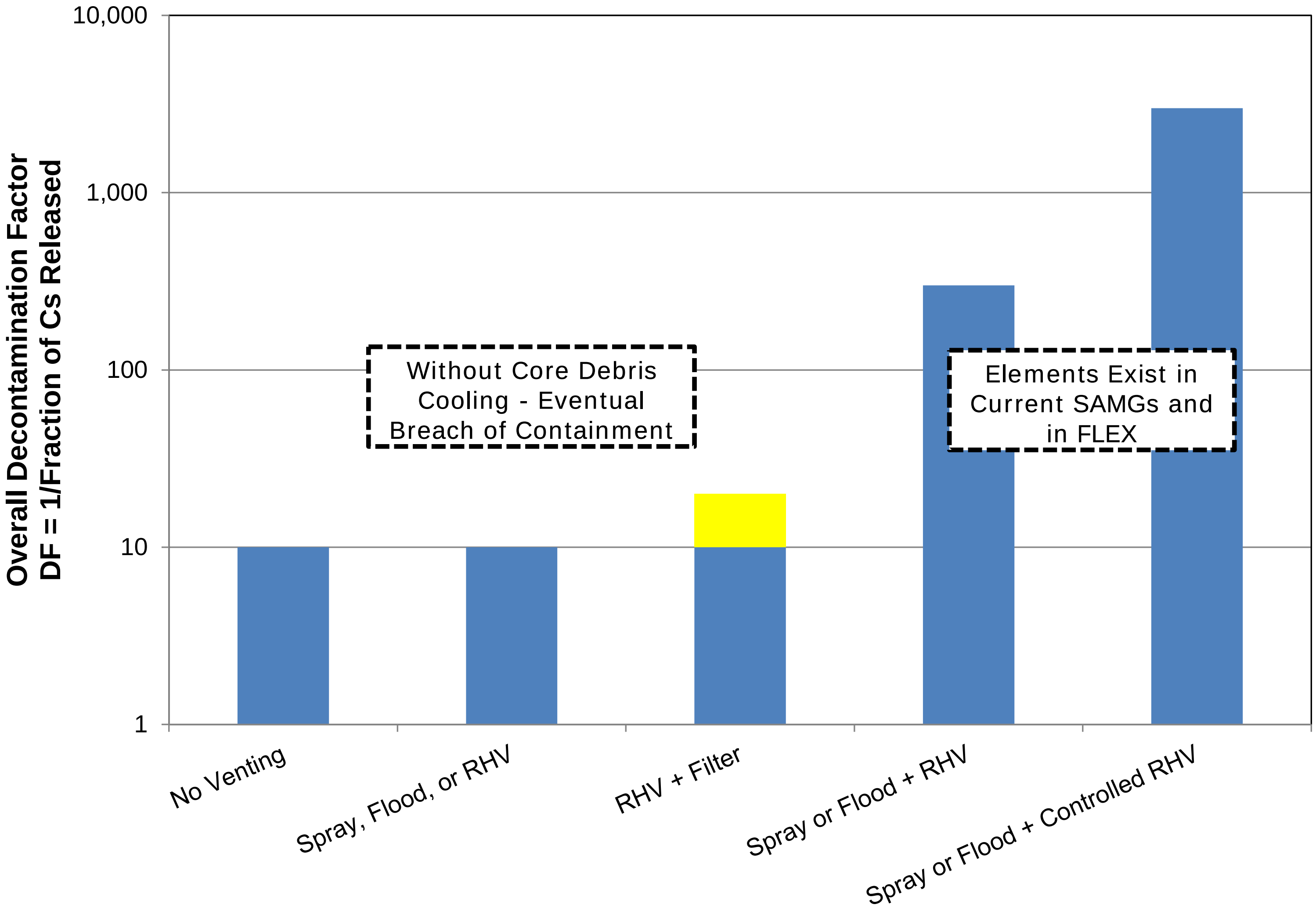
BACKUP SLIDES

Containment Filtering Strategies for BWR Mark I and II Plants

- Filtering strategies have been developed through an initiative to provide the best, safest and most comprehensive methods to mitigate land contaminating releases from BWR Mark I and Mark II containments during severe events with a damaged core.
- The findings were released by the Electric Power Research Institute on Sept. 25, 2012, in a comprehensive technical report.
- The findings demonstrate that substantial decontamination factors for releases can be achieved by a comprehensive strategy that includes operator actions, installed equipment, and FLEX.

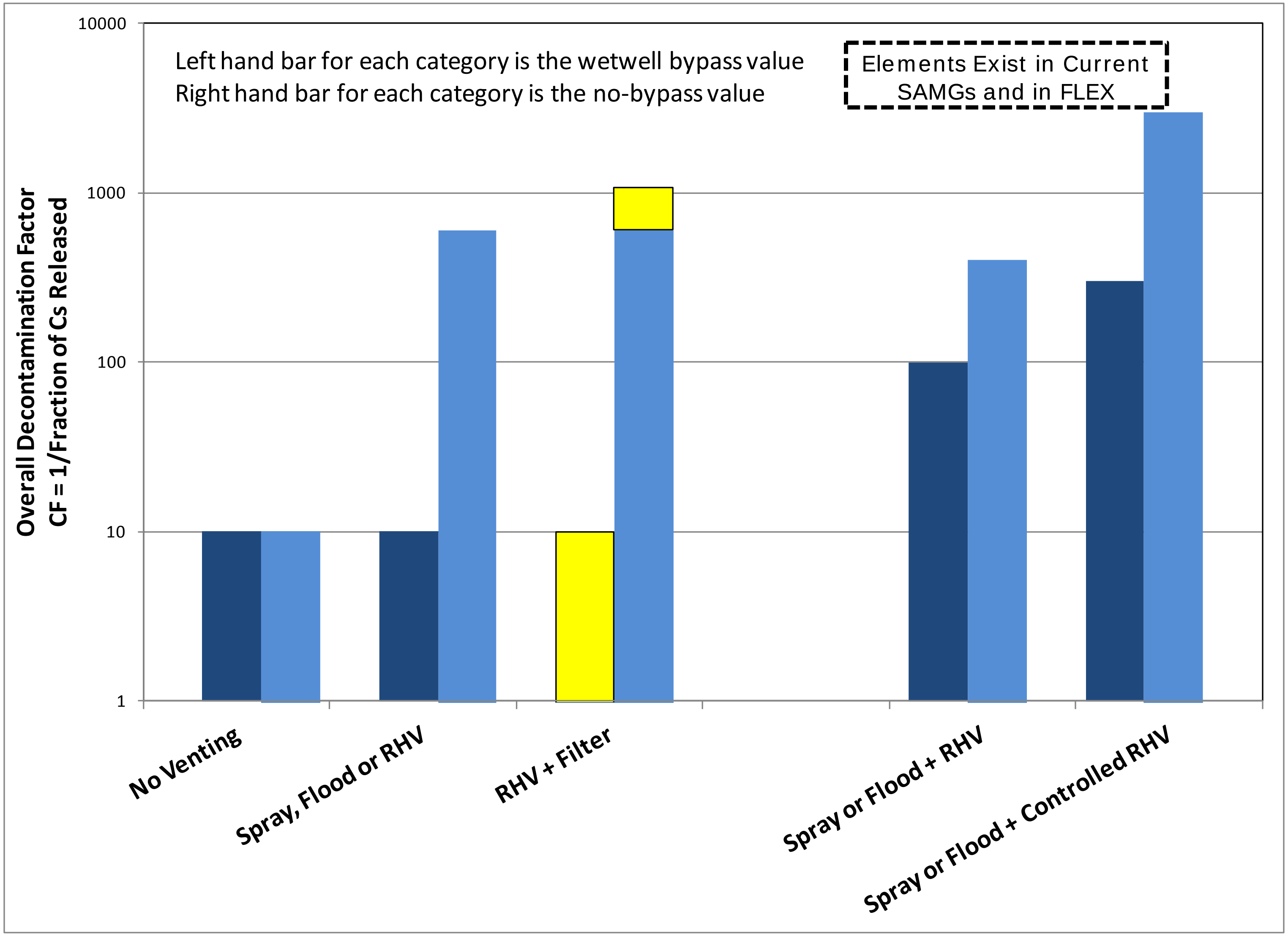
BWR Mark I Results

(EPRI 1026539)

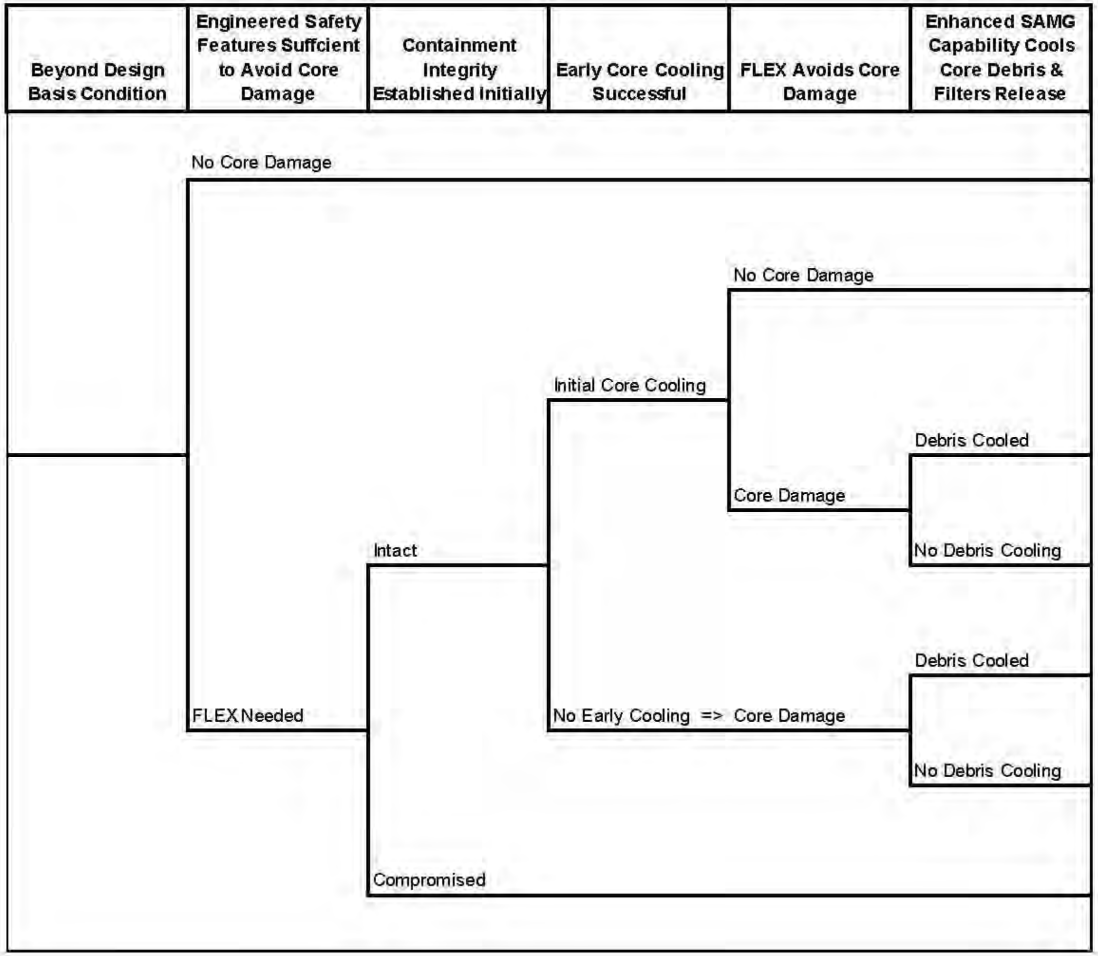


BWR Mark II Results

(EPRI 1026539)



Filtering Strategies Scenario Classification Event Tree

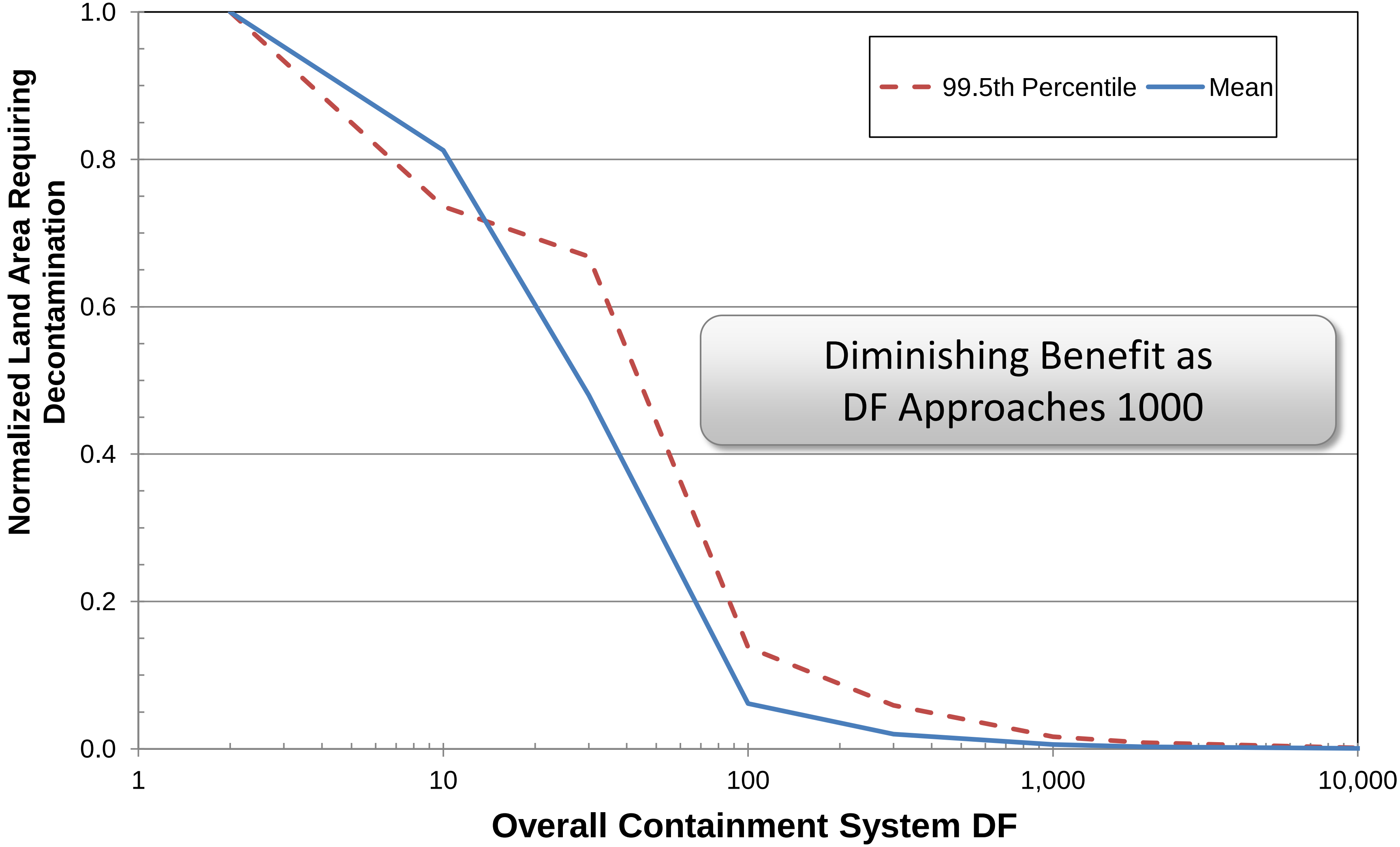


Seq.	Filtering Strategies Effective?	Comment
1	N/A	No core damage
2	N/A	No core damage
3	**Yes**	Debris cooled; filtering strategies effective; external filter could be effective
4	No	High temperature challenge of containment
5	**Yes**	Debris cooled; filtering strategies effective; external filter could be effective
6	No	High temperature challenge of containment
7	No	Containment compromised, filter ineffective

Failure Modes and Effects Analysis of Enhanced SAMG Capability

Functional Failure Mode	Failure Cause Leading to Core Damage	Effect on Enhanced SAMG Capability	Failure Cause Prevents Enhanced SAMG?	Relevant FLEX Provisions (NEI 12-06)
Early Core Cooling Fails	RCIC fails to operate until FLEX can be deployed	None	**NO**	---
	DC control power lost	None	**NO**	Capability to manually initiate RCIC required
	RCIC water source unavailable	None	**NO**	Essentially indefinite supply of water required.
	RPV instrumentation inadequate	None	**NO**	Reference source required for all available sources for required parameters
	Substantial LOCA occurs	None	**NO**	---
FLEX Deployment Ineffective	Operators do not diagnose need for FLEX	None	**NO**	FLEX interfaced with EOPs. Training and drill requirements
	Operators fail to deploy in a timely manner	None	**NO**	Training and drill requirements
	Difficulties transporting equipment	Could delay implementation	YES	Transport and debris removal equipment required
	FLEX deployment precluded by initiating event	Unavailable	YES	---
	SRVs fail to open to depressurize RPV	None	**NO**	---
	RPV injection paths impaired	None	**NO**	Primary and alternate injection path required
	Containment pressure instrumentation inadequate	Degraded capability. SAMG should address actions without instrumentation.	DEGRADED	Reference source required for all available sources for required parameters
	Wetwell vent fails to open	Wetwell vent required for SAMG	YES	EA 12-050 requirements
FLEX Equipment Failures	FLEX pump(s) fail to start	Degrades or fails enhanced SAMG	YES	N+1 pumps provided
	FLEX pump(s) fail to operate long-term	Degrades or fails enhanced SAMG	YES	N+1 pumps provided
	Essential supplies not replenished (e.g., fuel, water, etc.)	Long-term loss of enhanced SAMG	DEGRADED	Regional response center provides short-term and long-term supplies
	FLEX hoses fail	None. Separate hoses provided.	**NO**	---

Performance Basis
Decontamination Factor (DF)



CONSIDERATION OF ADDITIONAL REQUIREMENTS FOR CONTAINMENT VENTING SYSTEMS FOR BWRs WITH MARK I AND MARK II CONTAINMENTS

ACRS Subcommittee Meeting

October 31, 2012

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Purpose

- To discuss the staff's draft Commission paper and proposed recommendations on imposing new requirements related to containment venting systems for boiling water reactors with Mark I and Mark II containments

Agenda

- Taskings
- Schedule update
- Discussion of draft SECY paper and proposed recommendation

Tasking (1)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- SRM on SECY-11-0137, "Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned"
  - The staff should quickly shift the issue of "Filtration of Containment Vents" from the "additional issues" category and merge it with the Tier 1 issue of hardened vents for Mark I and Mark II containments such that the analysis and interaction with stakeholders needed to inform a decision on whether filtered vents should be required can be performed concurrently with the development of the technical bases, acceptance criteria, and design expectations for reliable hardened vents

Tasking (2)

- SRM from August 7, 2012 Commission Meeting on status of actions taken in response to lessons learned from the Fukushima Dai-ichi accident
  - In the forthcoming notation vote paper on filtered vents, the staff should include a discussion of accident sequences where the filters are and are not beneficial

Schedule

- Current Schedule
  - November 30 SECY Paper to Commission
  - November 20 SECY Paper to EDO
  - ACRS Interactions
    - November 1 Full Committee mtg
    - October 31 Subcommittee mtg
    - October 26 Draft Rev. 2 Commission Paper
    - October 19 Draft Rev. 1 Commission Paper
    - October Subcommittee mtg
    - September Subcommittee mtg
    - June Subcommittee mtg

Draft Paper Outline

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- SECY Main Paper and Enclosures
  1. Evaluation of Options
  2. Design and Regulatory History
  3. Foreign Experience
  4. BWR Mark I & II Containment Performance During Severe Accidents
  5. Technical Analyses (MELCOR/MACCS/PRA)
  6. Stakeholder Interactions
  7. Draft Orders

Main Paper

- Discuss issues associated with severe accident containment venting and relevance to Mark I and II containments
- Identify potential options
- Basis for staff's recommendation
- Discuss role of quantitative analysis and qualitative analysis
- Provide concise writeups referencing enclosures for details

Options Considered

1. No change (EA-12-050)
2. Severe accident capable vent
3. Filtered vent
4. Performance-based approach

Proposed Recommendation

- Option 3 – Filtered Vent
  - The NRC staff finds that the combination of quantitative and qualitative factors best supports the installation of filtered venting systems at BWRs with Mark I and II containments

Basis for Proposed Recommendation

- Cost-justified substantial safety enhancement
  - Quantitative analysis
  - Qualitative analysis
    - Enhances defense-in-depth (containment vulnerabilities and severe accident uncertainties)
    - Filter provides a fission product retention capability independent of plant accident response

Enclosure 1
Evaluation of Options

- Summary of considerations in decision-making
- Consideration of adequate protection
- Decision on substantial safety enhancement
- Inclusion of qualitative arguments
- Presentation of results including sensitivity analysis

Cost-Benefit Analysis

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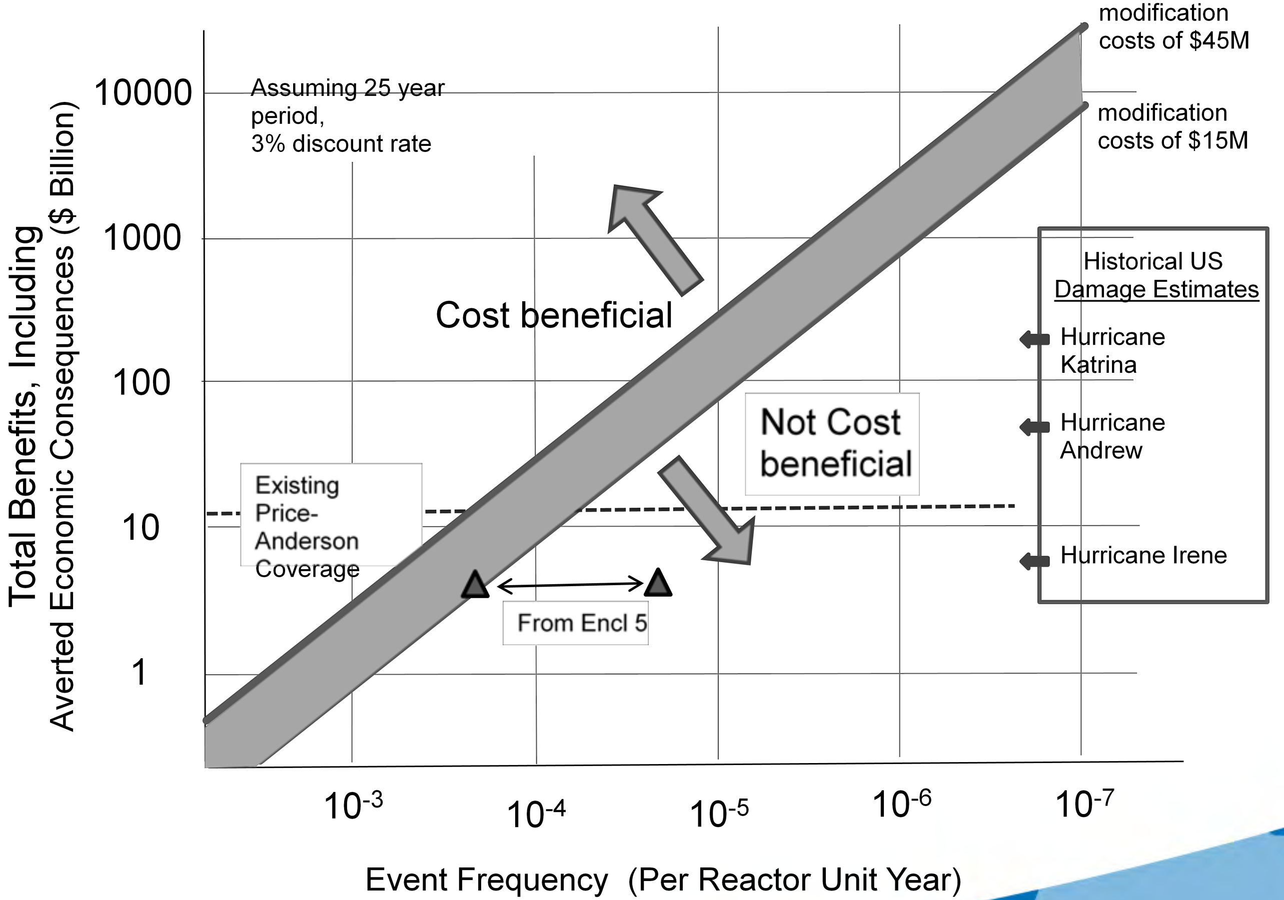
Quantitative Cost/Benefit Analysis Per Plant				
	Severe Accident Capable		Filtered	
Total Costs ($k)	(2,027)[1]		(16,127)	
Core Damage Frequency	$2x10^{-5}$yr	$2x10^{-4}$/yr	$2x10^{-5}$/yr	$2x10^{-4}$/yr
Total Benefits ($k)	938	9,380	1,648	16,480
Net Value (Benefits – Costs)	(1,089)	+7,353	(14,479)	+353

(1) As discussed in Enclosures 1 and 4, the costs for severe accident capable vents for Mark II containment designs will likely be higher. The higher cost reflects the likely need to modify the containments to prevent molten core debris in the lower drywell sump drain lines from causing a bypass of the suppression pool. Avoidance of wetwell bypass is needed to make the severe accident capable vents a viable option for the Mark II containment design.

Break Even Cost/Benefit Considerations



Qualitative Arguments

- Providing defense in depth
- Addressing significant uncertainties
- International experience and practices
- Supporting severe accident management and response
- Improving Emergency Preparedness
- Hydrogen control
- Severe Accident Policy Statement
- Independence of barriers
- Consistency between reactor technologies
- External events
- Multi-unit events

Enhances Defense-in-Depth

- Containment is an essential element of defense-in-depth
- Addresses high conditional containment failure probability
- Filtering compensates for the loss of the containment barrier due to venting
- Filtering improves confidence to depressurize containment to address other severe accident challenges

Uncertainties

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- Uncertainties in prevention and mitigation of severe accidents
  - Event frequency
  - Severe accident progression
  - Radiological consequences
  - Economic consequences

International Practices

- Extraordinary Meeting of Members of Convention on Nuclear Safety recommended “measures to ensure containment integrity, and filtration strategies and hydrogen management for the containment”
- Consistent with decisions of most European countries, Canada, Taiwan, and Japan

Severe Accident Management Decision Making

- Each option enhances the management of the accident by allowing operators to focus on recovery actions other than preventing gross containment failure
- Each proposed option provides some benefit but filtered systems are the simplest
- A performance-based approach could be integrated into other severe accident management activities and procedures

Emergency Planning

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- The most benefit in terms of reducing the demands on emergency planning would be associated with Option 3 (filter) while the proposed change with the least benefit would be from Option 2 (unfiltered venting)

Hydrogen

- Improves operator confidence in a “clean” release for hydrogen control
  - Allows early operator intervention to vent hydrogen and control containment pressure
  - Sustained lower pressure reduces leakage of hydrogen thru penetration seals
  - Decreased leakage reduces threat from hydrogen explosion to reactor building, spent fuel pool, and emergency responders

Severe Accident Policy Statement

- The Severe Accident Policy Statement specifies that severe accident design features could be imposed on operating reactors using the established backfit process
- The importance of the qualitative factors suggests a need to revisit portions of the current regulatory framework (including the Severe Accident Policy Statement)
- The status quo option fits the current policy statement and its traditional application

Independence of Barriers

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- Minimize dependencies and address the high conditional failure probability of Mark I and Mark II containments following a compromise of the preceding barriers (fuel and coolant system)
- The filtered system would provide the most independence while the unfiltered vent could result in large releases in the attempts to reduce containment overpressure conditions

Consistency Between Reactor Technologies

- While the proposed improvements to venting systems for BWRs with Mark I and II containments address a known weakness in the severe accident performance for those plants, the pursuit of these improvements without resolving broader issues (e.g., NTTF Recommendation 1 and Severe Accident Policy Statement) introduces the possibility for inconsistent treatment of severe accident capabilities for the various reactor technologies

External Events

- Beyond design basis external events such as the 2011 earthquake and tsunami will challenge normal and emergency power and cooling systems at a nuclear power plant
- There is a significant advantage to having installed equipment and/or strategies in place to address such events and conditions and thereby avoid the nuclear power plant compounding the consequences from the event

Multi-unit Events

- A concern highlighted by the Fukushima accident is conditions or events (e.g., external hazards) which challenge multiple units at a nuclear facility
- There is a significant advantage to having installed equipment and/or strategies in place to address such multi-unit events

Enclosure 2
Design and Regulatory History

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- Summarize the licensing and design considerations for Mark I and Mark II containments
- Why are Mark I and Mark II containments being discussed?
  - Ability of designs to withstand severe accident challenges
  - Defense in depth
  - Residual risk

Enclosure 2
Design and Regulatory History

- Mark I Containments
  - WASH-1400 & NUREG-1150 found that Mark I containments could be severely challenged if a severe accident occurred
  - Relatively small volume
    - Gas and steam buildup affect pressure more dramatically
  - BWR cores have ~3 times the quantity of zirconium as PWRs
    - Potential for hydrogen gas and containment pressurization

Enclosure 2
Design and Regulatory History

- Mark II Containments
  - Similar to Mark I, the most challenging severe accident sequences are station blackout and anticipated transients without scram
  - Risk profile dominated by early failure with a release that bypasses the suppression pool
  - Hardened venting was considered not beneficial because of unacceptable offsite consequences without an external filter like MVSS
  - Staff did not recommend generic backfit of hardened vent, but recommended a comprehensive evaluation as part of the IPE program

Enclosure 2
Design and Regulatory History

- Mark I Containments
  - Containment Performance Improvement Program
    - Determine what actions, if any, should be taken to reduce the vulnerability to severe accidents
    - Staff recommended
      - Improve hardened vent
      - Improve RPV depressurization system
      - Provide alternate water supply to RPV and drywell sprays
      - Improve emergency procedures and training
    - Commission approved hardened vent
    - Other recommendations evaluated as part of IPE program

Enclosure 3
Foreign Experience

- Status of filtered vents and regulatory basis in other countries
- Identify basis for pursuing filtered vents
- Identify any operational experience or adverse systems interactions

Enclosure 3
Foreign Experience

- Staff visited Sweden, Switzerland, and Canada
- Insights from visits and public meetings consistent with previous findings
  - 1988 CSNI Report 156, Specialists' Meeting on Filtered Containment Venting Systems
- Together, FCVS and containment flooding scrub fission products from core debris and remove decay heat

Enclosure 3
Foreign Experience

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- Technical Bases Summary
  - Manage severe accident overpressure challenges
  - Defense-in-depth to address uncertainties associated with severe accidents
  - Significantly reduce offsite release
- After Barsebäck filter was installed, subsequent filter costs considered low to modest

Enclosure 3
Foreign Experience

- Quantitative Bases Summary
  - Release performance goal
  - Risk informed
    - Level 1 frequencies low but not sufficient
    - After the decision, ensure equipment performance is acceptable generically and on plant-specific basis
      - Acceptable not judged quantitatively – "significantly reduce", "almost eliminate", etc.
      - Factored into emergency planning

Enclosure 3
Foreign Experience

FCVS Status at Non-U.S. BWR Facilities

FCVS Status	GE Mark I	GE Mark II	ABB Mark II	GE Mark III	Other	ABWR	Totals	
FCVS Operational	1	0	6	1	5	0	**13**	30%
Committed	6	7	0	5	4	3	**25**	57%
Considering	1	0	0	1	0	0	**2**	5%
No FCVS	2	2	0	0	0	0	**4**	9%
Non-U.S. Totals	**10**	**9**	**6**	**7**	**9**	**3**	**44**	

Enclosure 4
Mark I & II Severe Accident Performance

- Containment Spray Systems
- Containment Flooding
- Containment Venting
- Decontamination by Drywell Spray
- Decontamination by the Wetwell
- Mark I Containments
- Mark II Containments
- Decontamination by External Engineered Filter Systems
- EPRI Evaluation of Severe Accident Venting Strategies for Mitigation of Radiological Releases
- Passive Containment Vent Actuation Capability
- Early Venting

Enclosure 4
Mark I & II Severe Accident Performance

- EOPs, SAMGs, and EDMGs describe multiple containment vent pathways and use of portable pumps for reactor and drywell injection with focus on preventing core damage

Enclosure 4
Mark I & II Severe Accident Performance

- DW Sprays for Decontamination
  - Spray headers designed for DBA purposes (pressure control and heat removal) with flow rates of 1,000's GPM
  - Portable pumps with flow rates in low 100's GPM which is good for cavity flooding and not as effective for decontamination

Enclosure 4
Mark I & II Severe Accident Performance

- Suppression Pool for Decontamination
  - SRV discharge via T-quencher in bottom of subcooled suppression pool
  - Downcomer pipes which discharge higher in the suppression pool at or near saturation temperatures

Decontamination Factors

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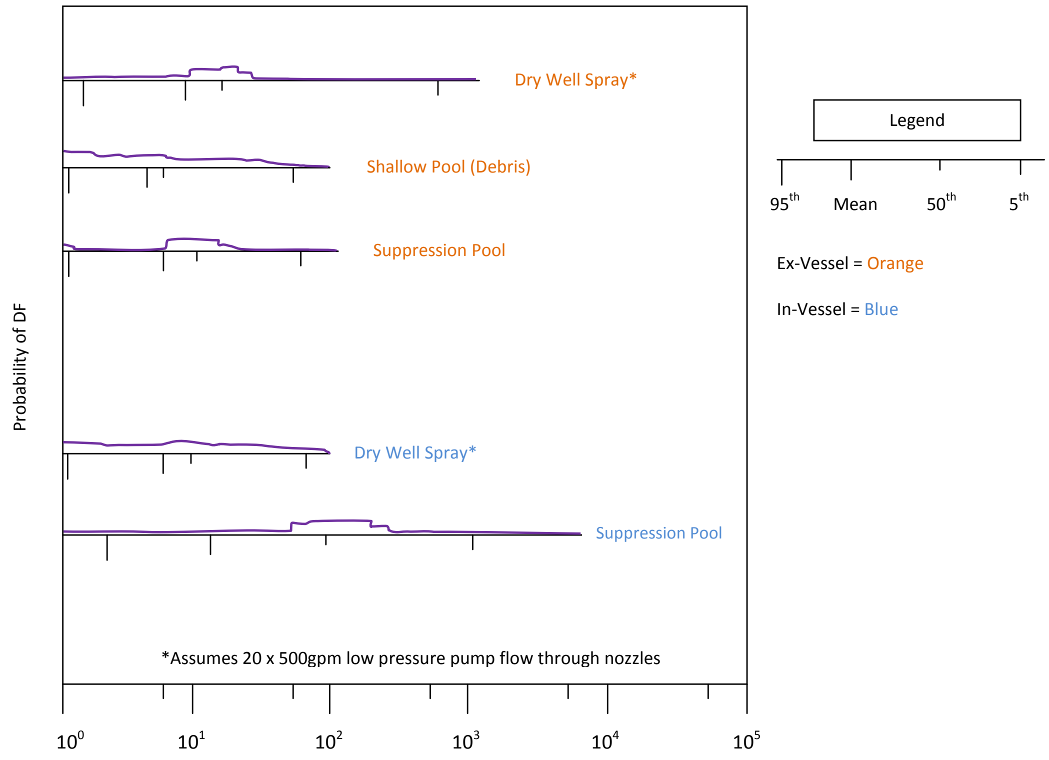

FIGURE 1: Uncertainty Distributions for Cesium Decontamination Factors (DFs)
Mark I Containment – Peach Bottom

Source: "Assessment of In-Containment Aerosol Removal Mechanisms."
BNL Technical Report L-1535, 1992

Enclosure 4
Mark I & II Severe Accident Performance

- EPRI Investigation of Strategies for Mitigating Radiological Releases in Severe Accidents
  - Employs a portable pump to flood drywell cavity and maintain suppression pool subcooling
  - Controls containment pressure near design value for holdup, settling, plate-out, spray effect, and high velocity discharge into suppression pool
  - Cycles containment vent valves to maintain containment pressure band (substantial reliance on instrumentation, valves/actuators, and operator actions)
  - Swap-over from WW to DW vent after 20 hours as containment floods up

Enclosure 5a
MELCOR

- Based on SOARCA MELCOR modeling
- Accident sequences
  - Informed by SOARCA and Fukushima
  - Long-term SBO (base case 16 hr RCIC)
- Mitigation actions
  - B.5.b and/or FLEX provide core spray or drywell spray (300 gpm)
  - Containment venting
- Sensitivity analysis
  - Spray flow rate and timing, wetwell versus drywell venting, and RCIC duration

Insights from MELCOR Calculations

- Water on the drywell floor is needed to prevent liner melt-through
  - Also scrubs fission products and reduces drywell temperature
- Venting prevents over-pressurization failure
  - Wetwell venting is preferable to drywell venting
- Need combination of venting and drywell flooding
  - More reduction in fission product release
  - Maintain reactor building integrity

Enclosure 5b
MACCS2

- Offsite population doses, including doses to off-site decontamination workers
- Individual latent cancer fatality risk and prompt fatality risk
- Land contamination
- For different thresholds of Cs-137 concentration in soil (Ci/km2)
- Economic costs

Insights from MACCS2 Calculations

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- The health effect of interest is latent cancer fatality risk, which is controlled in part by the habitability (return) criterion
  - Essentially no prompt fatality risk
- In terms of long-term radiation, the most important isotope is Cs-137, and most of the doses are from ground shine
- There is a non-linear relationship between decontamination factor and both land contamination area, health effects, and economic consequences

Enclosure 5c
PRA

- Conditional containment failure probability
- Insights from Severe Accident Mitigation Alternatives (SAMA) Analyses
- Technical approach
- Results
- Uncertainties

Enclosure 5c
PRA

- To estimate the risk reduction resulting from installation of a severe accident containment vent for use in regulatory analysis
  - 50-mile population dose (Δperson-rem/ry)
  - 50-mile offsite cost (Δ$/ry)
  - Onsite worker dose risk (Δperson-rem/ry)
  - Onsite cost risk (Δ$/ry)
  - Land contamination (Δconditional contaminated land area)

Enclosure 6
Stakeholder Interactions

- Numerous public meetings
- Stakeholder input and presentations
  - Filter vendors
  - Public interest groups
  - Regulated industry

Enclosure 7
Draft Orders

- Considerations
  - Assessing proposed implementation date
  - Provide high level technical requirements
  - Detailed guidance document to be developed with consideration of stakeholder input

Previous ACRS Questions

- Uncertainties on particle removal capabilities
  - Discussed in Enclosures 4 and 5a
  - Particle removal efficiency is dependent upon various parameters including particle size
  - Submicron particles are difficult to remove
  - Uncertainty in particle size distribution given an accident

Previous ACRS Questions

- Impact of noble gases on site operations
  - Elevated release with stable meteorological conditions have a relatively low impact
  - Elevated release with unstable meteorological conditions (i.e., plume washdown to site) would have greater impact
    - Shielded locations should limit doses to regulatory limits

Conclusions

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- The NRC staff finds that the combination of quantitative and qualitative factors best supports the installation of filtered venting systems at BWRs with Mark I and II containments (Option 3)