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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

April 21, 2006

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

SUBCOMMITTEE ON RELIABILITY AND PROBABILISTIC

RISK ASSESSMENT

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FRIDAY, APRIL 21, 2006

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ROCKVILLE, MARYLAND

The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T-2B1, 11545 Rockville Pike, at 8:30 a.m., George E. Apostolakis, Chairman, presiding.

COMMITTEE MEMBERS:

GEORGE E. APOSTOLAKIS	Chairman
J. SAM ARMIJO	Member
MARIO V. BONACA	Member
RICHARD S. DENNING	Member
THOMAS S. KRESS	Member
OTTO L. MAYNARD	Member
WILLIAM J. SHACK	Member
JOHN D. SIEBER	Member
GRAHAM B. WALLIS	Member

NRC STAFF PRESENT:

Sud Basu, RES/DRASP

Amy Cubbage, NRR

Jim Gaslevic, NRR/DNRL

Bob Palla, NRR/DNA

Marie Pohida, NRR/DRA/APOB

Larry Rossbach, NRR/DNRL/NESB

Nick Saltos, NRR/DNA

See Meng Wong, NRR/DRA/APOB

ALSO PRESENT:

David Hinds, GE

Mohsen Khatib-Rahbar

Theo Theofanous, GE

Rick Wachowiak, GE

Zhe Yuan, REI

INDEX

AGENDA ITEM	PAGE
External Events Risk Management, GE	5
Fire Analysis	
Flood Analysis	
High Wind Analysis	
Seismic analysis	
Shutdown Events Risk Management, GE	81
Design features to prevent core damage	
Analysis methodology	
System success criteria	
Results and conclusions	
ESBWR Risk Management Insights, GE	96
Overall results and conclusions	
Review of commitments from the meeting	
Requests for Additional Information, NRR	101
ESBWR Severe Accident Analysis, RES	122
Adjourn	137

P R O C E E D I N G S

Time: 8:33 a.m.

CHAIRMAN APOSTOLAKIS: The meeting will now come to order. This is the second day of the meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Probabilistic Risk Assessment. I am George Apostolakis, Chairman of the Subcommittee.

Members in attendance are Graham Wallis, William Shack, Sam Armijo, Mario Bonaca, Rich Denning, Tom Kress, Otto Maynard, and Jack Sieber.

The purpose of the meeting is to begin our review of the ESBWR probabilistic risk assessment. The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions, as appropriate, for deliberation by the full Committee.

Eric Thornsbury is the designated Federal official for this meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting, previously published in the Federal Register on April 4, 2006.

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

Register notice. It is requested that speakers first identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

We have received no written comments or requests for time to make oral statements from members of the public regarding today's meeting.

We will now proceed with the meeting, and I call upon Mr. Rick Wachowiak to begin the presentations. Rick.

MR. WACHOWIAK: All right. I would like also to say that from GE this morning, we have David Hinds and Sid Bhatt in attendance also.

Well, this morning we are going to talk about a couple of things. We are going to talk about external events in the DCD PRA, and then a little later on this morning we are going to talk about the shutdown PRA.

Now these are kind of intermingled, because in our -- the way that we are writing the document now in the fire and flood analysis we've got the fire and the shutdown fire in the same chapter, and then the flood and the shutdown flood in the same chapter. So it may seem like I am jumping around a little bit, but I am trying to keep it in the spirit of how we arranged the presentation here.

So let's start out with the probabilistic fire analysis. We have done a screening analysis to show that the contribution of risk due to fire is going to be not significant in the ESBWR design. We chose the five methodologies to provide the basis for identifying the fire compartments, defining the fire ignition frequencies. Those are consistent with what we have done in the rest of the PRA where we used generic --

MR. WALLIS: Well, you don't explain how you reached this conclusion, because in existing plants fire risk is often comparable with the regular risks, and I'm not sure why your plant is any different. What is it that makes it different was not clear to me.

CHAIRMAN APOSTOLAKIS: Not only that, but to find something insignificant when your base is 10^{-8}. This is now, what, 10^{-11}.

MR. WACHOWIAK: Well, we are going to cover exactly those things.

One of the things that, and it probably prompts your question, is this definition here. Risk of core damage due to fire in each of the area groups -- and we will talk about area groups in a minute -- should be lower than the risk of core damage due to internal events.

Now thinking about that, is that the right way to pose that? I would say that, no, we didn't pose that quite right. What we should have said here was that either the total of the fire risk in the screening analysis needs to be much less than the internal event CDF or each individual group, using this conservative screening analysis, needs to be much, much less than.

In Rev-0 it turned out that each individual group was much, much less, and we will talk about one sequence in Rev-1 that doesn't come out quite that way, and we can explain why.

So this was in Rev-0 of the document. We will be changing that to be the correct one. Now when we come into how does the ESBWR get to have a lower fire risk or a lower contribution than existing plants, there's a couple of different things that play into this.

Number one, at the design phase it is pretty easy to say that everything is separated, and it was easy to say that in the existing plants when they were at the design phase. Right? And it was when they actually pulled the cables and set things out in the actual field that caused some of the problems that are associated with fire risk.

We understand that now in the industry. that is a well known issue. So as part of the detailed design of the ESBWR, we are saying you don't get to field route stuff the way you did before. It's got to match the fire hazards analysis and the routing that we put into the design. That is a criteria that we have to meet. It can't be deviated, and it leads to being able to preserve the types of risk levels that we are going to see here.

The other thing is that many of the -- The instrument control system that we are using in this plant, the digital instrument control system connected by fiber optics, is not subject to the same kind of failure modes and adverse actions that the actual cable connections do.

Now there's some other issues with what happens to printed circuit cards and things like that, but we think that we are less susceptible to things like hot shorts and other things that cause actions that you wouldn't necessarily consider. So that's some of the reasons.

CHAIRMAN APOSTOLAKIS: You show here that fire is indeed a negligible contributor. That means that at the COL stage they will not have to worry about fire? If the design is certified, fires are out.

MR. WACHOWIAK: That would help me out.

CHAIRMAN APOSTOLAKIS: Sorry?

MR. WACHOWIAK: That would help me out in meeting the schedule, but I expect that we will have to provide a similar sort of analysis at the COL stage to show that it remains negligible, and I would expect as we go forward and build the plant, we will continue to have to show that it remains negligible or include it, if for some reason there is some component that we actually have to buy, implement something that has a failure mode that we never thought of before.

CHAIRMAN APOSTOLAKIS: I understand that. The question is more from the legal side. When you set the fire down, then I guess you are not allowed to revisit certain issues. That's the whole idea. Otherwise, you start everything from scratch.

So I am wondering, if you have a situation like this, is it -- Yes, Amy, please?

DR. DENNING: She is afraid to get up.

MS. CUBBAGE: Well, this would be more in the mode of verification through the ITAAC that they have implemented the design as certified.

DR. KRESS: Well, it would have to show up in an ITAAC.

MS. CUBBAGE: We would have to have sufficient ITAACs that we could verify that the as-built plan conforms to the regulations and the license.

DR. WALLIS: Now you said that you got this low risk by using fiber optics instead of copper, but I believe your PRA assumes copper. It says you are not taking credit for fiber optics.

MR. WACHOWIAK: Well, what we said -- What I believe we said was that --

DR. WALLIS: It assumes copper conductors is what I read, instead of fiber optics.

MR. WACHOWIAK: In Revision 0 we did say that we assumed copper.

DR. WALLIS: But you are not assuming fiber optics?

MR. WACHOWIAK: What we are assuming is that, even though we have fiber optics, we are going to include a -- what we will call bounding or worst case spurious actuation due to some unknown means.

DR. DENNING: Now is that only the actuation of one SRV? Is that the only actuation, spurious actuation, you are saying?

MR. WACHOWIAK: It's a spurious actuation of a relief valve. It doesn't necessarily have to be an SRV. It can be an SRV or a DPV, but the reason that one is more remedying than, let's say, all is that one is sufficient to remove the isolation condenser as a viable heat removal source; or that is also not sufficient to depressurize the plant so that GDS can come in without further depressurization.

So if we assume one, it gets us into a situation where it is essentially the worst case. If we assume a whole bunch, then GDCS can come on all by itself, and we don't have to worry about the passive syndrome. If we assume none, then isolation condensers work just fine.

So we chose to use limited depressurization in this, just for that purpose.

DR. DENNING: As far as the controlling of cables and things like that in isolation, does that only relate to the passive safety systems? It isn't clear to me. What happens to those active systems that you use for asset protection? Are they trained in the same sense and do they have separation or is that not relevant to that?

MR. WACHOWIAK: It is relevant, and we will see through some of these analyses where it can make a difference. It determines how much credit we can get for some of these things.

In our composite spec for the plant, which is the like overarching design spec, it's got some things that we need to meet. There is a list of systems in there that we call the plant asset protection systems, and what we specified is that, to the degree possible, we will provide electrical separation, physical separation, purchased to seismic pipe specifications for those pieces of equipment to provide reasonable assurance that we are not going to have a single fire event or flood event that is going to take out all those pieces of equipment.

So -- and the list of equipment is, in general, the stuff that, if we had the active systems, that are modeled in the PRA. So we do have separation of the nondivisional side for those.

So far, the design implements that. Now once again, this is where we are early in the design phase, and I guess I understand now that this is something that is -- we have to deal with as we add the detail to the design, and everything on the drawing board now shows that they are separated, and I guess we need to maintain that.

DR. BONACA: I have a question regarding the ITAAC, just to understand it. You cannot impose on GE more than the Code of Regulations protections applies. So if GE comes in with an analysis and the fire risk of, we could say, two percent for CDF, and then later on it goes out to five percent or eight percent --

MS. CUBBAGE: We would be in the position of verifying that they are in conformance with the regulations.

DR. BONACA: That's right. So they still really can change the results quite significantly and still be in conformance with the regulations. So I can't understand --

MS. CUBBAGE: Nick Saltos, come on up here, Nick, to the mike, please.

MR. SALTOS: This is Nick Saltos from NRR. What we do at this stage, we identify those design features. For example, separation, diversity, redundancy are the features that make the risk be so low, as they said, and those become part of the ITAAC or become action items.

So the plant has to meet these requirements.

CHAIRMAN APOSTOLAKIS: But if it does, then there is a presumption that the results of this preliminary analysis are correct, and how do we know that, if they do a fire assessment, risk assessment of the plant as it is being built will actually conform with this.

MR. SALTOS: The fire analysis right now should be conservative. Yes.

CHAIRMAN APOSTOLAKIS: So we are not going back to it. That's the thing. As long as they meet what they are saying --

MR. SALTOS: Well, there are many uses to address before these numbers stay the way they are. There is propagation of fire in the adjacent fire areas which have not been addressed. There is smoke. It can propagate also in the back, in the front.

MS. CUBBAGE: Those issues will be reviewed -

MR. SALTOS: There are several arteries. There is regulatory treatment of non-safety system, doing the fire PRA without the non-safety systems. So out of all these exercises they are going through, this risk might increase; but in any case, we are going to capture all these features that make this risk be gone.

Now, hell, no, we are not speaking to a number like that. What is important is for the fire, the design features that make these number low, but how low we don't know yet.

MS. CUBBAGE: All of that happens as part of the certification process.

CHAIRMAN APOSTOLAKIS: Well, it's Part 52 that applies here. Right? All it says is that they have to cut a PRA. Isn't that what it says?

MS. CUBBAGE: Right, but all it says --

CHAIRMAN APOSTOLAKIS: It doesn't say anything else.

MR. SALTOS: It says that they have to have a PRA, 35 important -- But also we use the PRA to identify requirements for the design.

CHAIRMAN APOSTOLAKIS: I understand that.

MR. SALTOS: All the assumptions that are made in the PRA are important assumptions that make the risk be low. We are making sure that they go into the ITAAC, all serial action items or liabilities to a problem or tech specs. So when they identify them, it will be according to those requirements -- will meet those requirements.

MS. CUBBAGE: And don't forget, this is the risk aspect of your review. We also have the fire protection engineering review.

CHAIRMAN APOSTOLAKIS: I understand. I guess it is not very clear to me. You certify the design, that you are not allowed -- I mean, the whole idea of the certification process is not to start the process all over again when an applicant comes with a real application, but is the PRA part of that or should you say, yes, the design has been certified, but we would like the PRA to be really updated as we move on?

MR. SALTOS: The PRA is part of it.

CHAIRMAN APOSTOLAKIS: Part of that certification?

MR. SALTOS: Yes, because ensuring that all the design features wanted in the PRA that make the risk -- the applicant below. They are going to be there, and the design is -- The plant is going to be built according to those requirements.

CHAIRMAN APOSTOLAKIS: Fine. That's one part. The other part is, yeah, you have built it that way, but update your PRA to take into account now details that were not in the original design certification phase, because we didn't have all that information.

MR. SALTOS: Oh, yes.

MS. CUBBAGE: I think we are still working through the issues of what would be reviewed at the COL stage of our NPRA, and I think that is kind of offline.

MR. SALTOS; Yes, but the PRA also makes assumptions, for example, about if there is some failure caused by cables being close together, we come up with requirements that the cables have to be separated up to a certain distance or in different fire areas.

So all this information goes in there. Now unless we miss something, the PRA is high, top level assumptions that make the PRA conservative, bounding, so in an average sense at least.

DR. SHACK: A licensee, if he is coming in for a 1174 action, he is going to have his own PRA. Now presumably, it is going to be built on this PRA, but it is going to have to be verified that it is plant specific and been reviewed.

MS. CUBBAGE: Right. I think the issue you are getting to is what will change at the COL stage, and I think Rick was speaking more to the fact that this PRA is going to have to evolve with this as-built plan so that it can be a tool used by the licensee. But whether we get it back into the review again at the COL stage, I think, in general is no.

MR. SALTOS: Well, it has to meet the requirements.

MS. CUBBAGE: Right, and that's --

MR. SALTOS: That's what we said. Now if they want to argue the case about how they route some cables or some other design details, but they still will have to meet those requirements, high level requirements.

MS. CUBBAGE: But the question is an updated PRA.

MR. SALTOS: They may choose not to update it.

CHAIRMAN APOSTOLAKIS: That is what worries me.

MR. SIEBER: Well, there is no rule that makes anybody do that.

CHAIRMAN APOSTOLAKIS: Or not do that. See, that's the point. The rule is not specific.

MR. SIEBER: That's right. You can do it if you wanted to or --

CHAIRMAN APOSTOLAKIS: Well, the question is -- Rick showed yesterday a very nice slide where you had five or six columns, the evolution of the design. right? You start with a very conceptual stage, and then you move on.

As you move on, then, obviously, the PRA changes, too, because you have more information. So what is it -- My question is: Let's say we all certify this. You guys agree, and your SER, the ACRS agrees with the letter and so on.

That means then that at a later stage, if we raise a question about, say, common cause failure, you can come back and say, wait a minute now, you reviewed that last time and you have certified it; don't even raise questions anymore.

MR. SIEBER: I don't think that's right, John.

CHAIRMAN APOSTOLAKIS: Well, I don't understand. That's what I am trying to understand.

MR. SIEBER: Well, the NRC is going to certify a design. They are not going to certify the PRA.

CHAIRMAN APOSTOLAKIS: Well, that's exactly the question.

MR. SIEBER: Okay.

CHAIRMAN APOSTOLAKIS: Is the PRA part of the certification?

MR. SIEBER: No, only in how it resulted in design of the thing. That's what we certify, is the design. The PRA is just a tool they use with designing. We aren't going to certify that.

CHAIRMAN APOSTOLAKIS: But what if, in the

COL things, they don't even submit a PRA?

MR. SIEBER: Well, they don't have to, but if there is something that shows up --

MS. CUBBAGE: I think it is a requirement.

MR. SIEBER: Well, maybe.

CHAIRMAN APOSTOLAKIS: It is a requirement. Why do you say it is not?

MR. WACHOWIAK: It is on the list of documents to be provided by the applicant.

CHAIRMAN APOSTOLAKIS: That's right. The question is how up to date should it be? I'm sorry, go ahead.

MS. CUBBAGE: Yes, there is a whole other effort going on to look at what would need to be submitted in the COL.

CHAIRMAN APOSTOLAKIS: Okay. So it is kind of open right now.

MS. CUBBAGE: Yes. That's why I'm kind -- and they are still -- We are in the process of a Part 52 rulemaking right now, and we are in the comment period.

CHAIRMAN APOSTOLAKIS: Well, that is the one where -- Sorry, Nick. go ahead.

MR. SIEBER It's a good question.

MR. SALTOS: Any difference that exists between the specification, the PRA and the actual plant here -- it has to be submitted, site specific characteristics. So any design changes, more details about the route of cabling and the piping and things like that have to be submitted at the COL stage. But it does not mean that they have to be updated for everything. If there is no PRA at the certification period, it is bounding.

MS. CUBBAGE: And you are saying, if you identified a common cause of failure that was not reviewed as part of the certification, if it rose to the level of an adequate protection issue or a compliance issue, we would have the forms back that certify the design.

CHAIRMAN APOSTOLAKIS: Well, let's say that it is not an issue of adequate protection. I mean, to reach that level is really hard. But suppose that we look more carefully. We have a plant specific PRA, and the core damage frequency now is 10^{-7}. Okay? An order of magnitude greater, still very low but --

MS. CUBBAGE: That's an issue, a compliance issue, and they have met the ITAAC. We're done.

CHAIRMAN APOSTOLAKIS: So the only chance in the future will be if the licensee wants to come back and invoke Regulatory Guide 1174, in which case, of course, they have to have a good PRA.

MR. SIEBER: T hat's a choice.

MR. SALTOS: But they can demonstrate, though -- They can demonstrate that the assumptions they were making in the certification PRA, they were bounding, and any details having to do with -- about piping and cabling and things like that, and site characteristics, they are in the law by the assumptions they are making in the certification PRA, and the only way there is to go is down, not up. Then they conclude not to make changes to the PRA.

CHAIRMAN APOSTOLAKIS: Well, yes, what you are saying is that, even if they do all these things, and even if they update it, it would be the same. That's really what you are saying.

DR. WALLIS: Well, this may be true of fires, but I am not at all sure that the assumption that this core capture works with 99 percent efficiency is bounding. You keep using the word bounding, but I mean --

DR. BONACA: That opens up the issue of, again, what is within the licensing basis and even beyond the licensing basis. Are they bound, you know, in the results for --

MS. CUBBAGE: If the design feature is a BiMAC, they would be bound to that. That was provided in the whole document, and they would have to.

DR. BONACA: Yes, and I understand that. Of course, they wrote that. But the results of whatever they configure, I mean they vary once you begin to do more accurate calculations. So --

MS. CUBBAGE: That's a regulatory issue we will have to deal with during the review, and you will be hearing about it then.

MR. WACHOWIAK: One of the things that I had to save for my second or third to last slide for the day -- One of the things that is difficult with using the PRA in this manner or including it in the submittal at this point in the design is that the PRA is a little bit of a different animal than the design basis analysis.

In the design basis analysis, you say what has to happen, and you impose on that nonmechanistic failures of a limited manner and you say, okay, if you have any one failure -- And so it is easy going from a preliminary design to a final design and keep that framework intact.

CHAIRMAN APOSTOLAKIS: That's correct.

MR. WACHOWIAK: In the PRA, though, we are trying to figure out -- We know what is supposed to happen, but what we also try to figure out is what can go wrong, and changing the details can change what can go wrong.

So if we, for example, which we may talk about later, we have our turbine building, and we had everything laid out. We looked at what the worst case flood scenario is, and on paper originally it looked like it was a circ water line break -- okay? -- because so much water can get to anything. But now we see as they are building the actual rooms and things inside the building design, we find out that that flood has been isolated and ported to the outside.

This interior wall that wasn't originally part of the design now greatly affects in this particular one in a good direction what is in the PRA.

DR. SHACK: Was that wall added to address that?

MR. WACHOWIAK: No, no. It was added, because they were putting the walls in the building now. We didn't have that at the original. We are finishing in the details on the picture.

Then there are other places where we may find that there is some failure mode inherent to equipment that is able to be purchased that we didn't think about before. So this failure mode would have to go in, and it could take us the other direction.

Now what we have tried to do in these uncertain things with external events -- Let me back up. With internal events, I think we have been working with PRA internal events on the mechanical systems and these electrical systems for -- I don't know. I've been messing with it for almost 20 years, and people have been working on it for a long time, and we think we know what we are going to see when we go and actually put equipment in.

On some of these new systems like the digital I&C and things like that, we are not quite sure what is going to happen. So we try to do things like this where we bound it.

We say, we will use what we think are bounding assumptions and come up with values that are low using bounding assumptions, so that later when we rough in the details or fill in the details from our rough idea that, yeah, maybe we have to refine some of this. We can't just use five. Maybe we have to do some fire propagation modeling or something, but in the end the conclusion still comes out to be the same.

Your point is a good one, though. If we

do this certification using this method and then, to get to the final answer we have to use a different method, where does that put Nick, the reviewer, in this then?

MR. SALTOS: Well, you still have to meet the assumptions. You are going to meet the assumptions that you make in the certification. You will not change this afterward.

CHAIRMAN APOSTOLAKIS: No, but they will make a difference, because --

MR. SALTOS: We might have to make some different assumptions.

CHAIRMAN APOSTOLAKIS: Then you review it again.

MR. SALTOS: We will come up with some additional requirements at the COL stage.

DR. BONACA: I need to understand better. You said something about the core capture now, and there will be commitments based on that, because they put it in their design. So now there is another manufacturer that comes in tomorrow and has a design that still has a core damage frequency of 10^{-8} and has no core capture. Okay, are you certifying that design?

MS. CUBBAGE: Do you mean different plant altogether?

DR. BONACA: Say there is another BWR designer that comes in with a design, and there is no core capture, but -- What is the regulation? I mean, you probably would certify that, too, because I mean, if you can convince yourself that there is such a low risk.

So I am trying to understand, you know. Until now, it see ms to me, the regulation was very specific on what you had to do, and what you do beyond that was like out of the -- discretionary. But it seems to me now that the process we are using to define different requirements is based on what the promise from the designer is.

I can't understand. What is the requirement for a core capture?

MS. CUBBAGE: Well, I guess Rick is going to speak to -- maybe not today, but at some point in the future, what happens if the core capture doesn't work, and what would happen to the PRA results, the Level II results. I don't know.

MR. SIEBER: What does the NRC require? I guess -- I think that's the question Mario is asking.

MS. CUBBAGE: We can do this later when --

Let Rick get through this. We will come back to this.

DR. KRESS: It seems to me, though, it is something akin to ice condenser or suppression tube. They are not required, but if a designer chooses to come in with them, the staff will evaluate it and see if it meets the design basis.

DR. BONACA: Well, I heard something different here. I heard that the core capture, which we have seen, was not required for -- really is not required for the criteria we use to license plants today, because you have a core value --

DR. KRESS: Why wouldn't that invoke defensiveness?

MS. CUBBAGE: At Part 52, there are requirements to address failure accidents. So it has to address it, and the manner in which they do it is up to the choice of the designer.

MR. WACHOWIAK: There is all sorts of interesting questions associated with that now. Let's say, hypothetically, we come up with a way between now and when we build the plant to eliminate that 90 percent of the CDF that is associated with those low pressure events, and all the ones that we remove, though, are the ones that have low water level in the drywell, and all that's left are the ones with high water level in the drywell. What does that mean?

We have improved the plant, but we have challenged one of the acceptance criteria of a conditional containment failure probability. So how does that play into any of this?

DR. DENNING: Although, we don't really have a conditional -- I mean, people have talked about it, but we don't really have a conditional. We have an absolute at the moment. So you haven't made it worse in that respect.

CHAIRMAN APOSTOLAKIS: So why don't we go ahead now, and maybe we can come back to this.

MR. WACHOWIAK: The scope of the analysis that we have included basically are these particular buildings, and the reason that we picked these buildings are these are the buildings that contain the equipment that is modeled in the PRA. So we assume that any other buildings that are out there, they can burn.

One thing that is maybe a little different than that is where the diesel driven firewater pump is. We did screen that one out based on that not causing an initiating event. So even though it is in the PRA, it could give us a degraded state, it doesn't lead to any sort of challenge to the plant, and in the end that would be something like an A4 evaluation would need to deal with, with the operation.

CHAIRMAN APOSTOLAKIS: Let me understand that. It doesn't lead to any sort of initiating event?

MR. WACHOWIAK: The diesel driven fire pump is used as a backup to the backup to injection into the vessel and into the pools up on top. If we have a fire in that room, we may lose that level of redundancy, but it doesn't affect anything to do with the operation of the plant. So there is no perturbation there.

CHAIRMAN APOSTOLAKIS: The plant would not be shut down?

MR. WACHOWIAK: The plant would not be shut down. They would probably go into an LCO based on some fire protection thing, and they would have to get that repaired based on fire protection rules. We might go into a manual shutdown if they can't get it repaired in 30 days or something like that.

CHAIRMAN APOSTOLAKIS: But that's when you would do an A4 analysis.

MR. WACHOWIAK: We may do an A4 analysis. That would be -- I believe that is required of the Part 52 plans. I don't think 50-69 goes away, or does it?

In Rev. 1 they are including full power and shutdown modes, plant operation. We have added the shutdown -- or are in the process of adding the shutdown in response to an REI. it was pointed out, and I believe correctly, that we should have considered the shutdown mode for fire and flood, and that is ongoing.

We use bounding assumptions here. Now we are trying to compensate for the level of design detail where we are not really sure where things are, but we know in the design from the fire hazards analysis where they are supposed to go. So we don't know if a cable goes through this Div. 1 chase or this Div. 1 chase, but we know it is in one of those Div. 1 chases.

So what we did was we said that let's start with the fire. We will use a fire ignition frequency. We are not going to do any fire modeling at the first cut. Any fire that starts in any fire zone is going to cover everything in that fire zone. But then to cover the uncertainty of what is in each particular room in those zones, we are just going to say it gets everything in that division.

So even though the division may be on this corner, this corner or this corner -- they are not really like that, but even if it was like that, we would say it gets all of those, mainly because we don't really know the routing. So that is a bounding assumption that we have there.

We also didn't credit the fire protection system for suppressing the fire at this point. That is a detail that is unknown and, as we mentioned earlier, we postulated our worst case spurious actuation, which in the reactor building is the inadvertent open relief valve. In the -- trying to remember if there are any other buildings that have those. I don't believe -- Now in the control room we also postulated the inadvertent open relief valve.

DR. DENNING: What happens if you activate the squib that drains the gravitational -- the water pool?

MR. WACHOWIAK: Actuate the squib that drains the pool to actuate the BiMAC?

DR. DENNING: Yes.

MR. WACHOWIAK: That's a good question.

DR. WALLIS: It drains.

MR. WACHOWIAK: It would drain, and I think we would have to look at that, and we will have to look at how we protect against that. Right now, that is kind of covered under our blanket design assumption that it's got to be reliable under all credible sequences to actuate and to not spuriously actuate. So we would have to address that in the design and how that -- Maybe that equipment needs to be in separate special fire zones. I don't know.

DR. WALLIS: Does the explosive ignite in the scope valve in a fire?

MR. WACHOWIAK: Not necessarily. It depends on how the control system is set up.

MR. SIEBER: No, he is talking about the heat on the explosive.

MR. WACHOWIAK: Oh, the explosive is inside the drywell, inside the containment. The fire wouldn't be there, because that is a nitrogen environment. The fires are in other buildings outside your --

DR. WALLIS: So they don't affect the valving?

MR. WACHOWIAK: They don't affect the squib itself. it affects the control system.

DR. ARMIJO: The control system could activate the squib. Right?

MR. WACHOWIAK: The control system could activate the squib, and that is why that it needs to be diverse; because otherwise we would have a potentially greater impact if we, let's say, hook these squib valves into the normal ECCS digital control system. Then maybe some of those fires could cause activation of the deluge system, but the current thinking is that we are probably not going to be able to meet our goals if we connect it into the existing ECCS digital control system.

DR. DENNING: Now your assumption is the fire barriers are perfect. There is no -- You don't have any probability of failure or fault in a --

MR. WACHOWIAK: Let me put up this slide. In Revision 0, that was correct. We asserted that this assumption was bounding, and we didn't need to go there.

Now the question is, though, is there a worse case if the fire goes from this one compartment of Div. 1 to this other compartment of Div. 2? Is that worse than all of Div. 1 together going?

So in this current revision what we have done is we have postulated the failure of one fire barrier, and we have given a probability based on the latest EPRI fire PRA methodology. There is a table of data for fire barriers. We included that for the failure probability, and looked at propagating.

Now we also -- and this is probably overkill, I think, but we used the same assumption. if it propagated from 1 to 2, then we lose everything in 2, when in fact, it really would be a subset that I am not sure how we define at this point.

So we start getting into a place where we do that. Yeah, I understand that it is a realistic concern, but we made -- The conservative assumption here may be a little too conservative by the time we get to that point. So we got to figure out how to deal with that.

What we find in -- and I think in our results -- in the reactor building, for example, where we would have thought that that was the biggest concern, it didn't cause us a problem. All of these fire scenarios -- in all but one place, they are all 3 times 10^{-10}, 2 times 10^{-10}, -11, 12, truncated. they are all very small things except for one, the fire in the turbine building.

The fire in the turbine building is an interesting thing. the turbine building is huge. It contains a lot of equipment that can initiate fire. So it has a fairly high initiating frequency, but as we said before, we didn't have a lot of details on what was there.

So we said, okay, we will apply our assumptions: Fire in the turbine building gets everything. If that happens, what would that act like? The loss of feedwater. What was our highest or one of our highest core damage events? Loss of feedwater. And basically, what this does is, using all those assumptions, we end up with this sequence here that basically is a ratio of the loss of feedwater initiating event to the fire ignition in the turbine building initiating event. It is basically that same thing.

So we are trying to figure out what we need to do with this under that original statement there that the sum of all these needs to be less than the internal events CDF. It meant we didn't have to deal with this.

DR. WALLIS; I'm puzzled by this. I read the document. I felt the control room was the -9 event. I don't understand why all the fire scenarios have the lower than 3 and 10^{-10}.

MR. WACHOWIAK: We've looked at the fire in the control room event.

DR. WALLIS: Something changed since --

MR. WACHOWIAK: And it has changed since then.

DR. WALLIS: It's changed since the document I read. Okay.

MR. WACHOWIAK: Right. And unfortunately, that is one of the documents that we are still working on.

DR. WALLIS: So this is clearly a preliminary meeting.

MR. WACHOWIAK: For the most part, yes.

DR. WALLIS: We are going through the details.

MR. WACHOWIAK: And for us, this --

DR. WALLIS: It would be better if I hadn't read it at all, I think.

MS. CUBBAGE: Well, it is preliminary, because the staff hasn't reviewed it. There may be a lot of changes that may come from this, additionally.

MR. DENNING: But it is still worthwhile.

MS. CUBBAGE: So this was supposed to be an introductory.

MR. WACHOWIAK: We went through it in Rev. 0. We have got some feedback from the staff. As we were implementing this feedback, we made some changes to the model, and the changes that we made during that time frame affected the fire in the control room.

DR. WALLIS: If you have a fire in the

turbine building, it affects the entire building? I don't see how that can happen.

MR. WACHOWIAK: It can't. It can't. This is bounding assumption here. In this particular scenario, that bounding assumption is not appropriate. So we know it is lower than that. How much lower is something that we haven't gotten into yet, and that is part of the issue with trying to do these things in a bounding manner and trying to go through these with as little perturbation on the people who are adding in the detailed design of things. We don't want to have to force things to happen inside that building that really aren't going to -- we don't want to be a requirement later on.

We tried the bounding assumption. Maybe we will keep the bounding assumption. We don't know, and maybe we will keep it going on at 4 times 10^{-8} for CDF. That could be okay.

DR. DENNING: But if there is anyplace you can have a huge fire, that's where it is.

MR. WACHOWIAK: If there is anyplace for one, that's where it is. The question, though, is: Is a huge fire a sudden loss of feedwater? So there may be some small subset of fires that become a loss of feedwater, and the others are a loss of condenser.

Loss of condenser is clearly a more benign accident.

That's the kind of thing we would want to look at, but once again, the question is do we need to pursue it or is there some reason that we would want to look at that for optics? You know, let's say we get rid of all the internal events things, and now we've got fire. CDF is 10 times the internal events, CDF again and, you know, what does that do to what we -- It's really a balancing act to try to figure out how to do things with these external events at this stage.

DR. WALLIS: So you redesign the turbine building.

MR. SIEBER: It's pretty tough.

DR. WALLIS: Put another wall in there.

MR. WACHOWIAK: Maybe.

MR. SIEBER: You could have a lot of little turbines.

MR. WACHOWIAK: Well, but what we could do in that case is do a better separation of the feedwater room from the turbine building. That could be done, and maybe it is being done. We just don't know.

MR. SIEBER: It still comes from the hot well, which is connected to the turbines. That's where all the oil is.

MR. WACHOWIAK: Well, the issue that we have with the loss of feedwater isn't just because we lose feedwater. It's the sudden loss of feedwater that causes the problem in the PRA -- or that causes the scenario that leads to the numbers in the PRA.

So if we could somehow delay the total loss of feedwater, make it a staged loss of feedwater, we could make it better, too.

CHAIRMAN APOSTOLAKIS: What happens in the scenario that you are preventing -- with the squib valves? Did you dismiss that or you said you are going to look into it?

MR. WACHOWIAK: We are going to look into it. We don't -- didn't have any information yet on where any of that control equipment was. So now we've got the design requirement that it's got to be reliable to actuate and reliable to not actuate when it is not supposed to, and that would clearly fall into this fire category, not actuating when it is not supposed to.

The shutdown results: These are still for fire. They are still too preliminary for me to present at this point. We do have one insight from that that I will present in the shutdown -- as much as people don't like the word insight, but it --

MR. MAYNARD: Some of us don't like it.

MR. WACHOWIAK: Okay, but we think we have learned something from what we have done so far in the fire -- shutdown fire PRA.

MS. CUBBAGE: That's coming later today?

MR. WACHOWIAK: Later today? No, the shutdown discussion is coming later.

MS. CUBBAGE: Yes, okay.

MR. WACHOWIAK: Yes, and I put the insight from the fire during shutdown in the shutdown discussion.

CHAIRMAN APOSTOLAKIS: So but you are still doing this analysis?

MR. WACHOWIAK: We are still doing this analysis.

CHAIRMAN APOSTOLAKIS: So you are using the word insight correct. That means we are not done.

MR. WACHOWIAK: That's right. We are not done.

CHAIRMAN APOSTOLAKIS: It isn't real yet.

MR. WACHOWIAK: Okay. So let me move on to the probabilistic flooding analysis. Once again, we don't know a real lot about where everything goes in the building. So we had to make some sort of estimates, and we used experience with flooding in existing BWRs.

So there's data on there about how often there is a fire main break. There is data on there how often there is a circ water line break, and we applied those to our different buildings.

This is a little bounding here where the data says that the probability of a fire main break is -- I'm trying to remember the numbers -- somewhere around 3 times 10^{-3} per year, and what we did was we applied that 3 times 10^{-3} to every building. So we didn't try to apportion it, like you would if you tried to say what is the total.

CHAIRMAN APOSTOLAKIS: Let me raise another question here regarding the fire before we go on.

You said that a fire in the turbine building basically will cause loss of feedwater flow and that you go to that event tree.

MR. WACHOWIAK: It is that event tree with some other effects in there, too.

CHAIRMAN APOSTOLAKIS: Oh, that was the adjustments to the other --

MR. WACHOWIAK: Yes, there are other.

CHAIRMAN APOSTOLAKIS: -- and may be

possibly affected by the fire. Right?

MR. WACHOWIAK: Right. The reactor closed cooling water system is in there. So that system would be affected. The instrument air system is in there. So that system would be affected.

CHAIRMAN APOSTOLAKIS: Okay, because I was looking at the sequence. So you did that, and even if you do that, it's still 10^{-8}?

MR. WACHOWIAK: Yes. There are really secondary effects. It's the things that are contained in the reactor building are what are providing our protection in that scenario.

CHAIRMAN APOSTOLAKIS: Okay.

MR. WACHOWIAK: Okay. So the initiator for this is somewhat bounding, because now, instead of using the industry experience, we are using one, two, three, four, five, six times the industry experience, in effect. But we don't know where to apply all those things. So we just did them all and let it go at that.

We did include full power in shutdown modes for this, and we will talk about both of those modes here. We are far enough along in the shutdown to talk about it, at least.

MR. DENNING: What about design

principles? I mean, that's what is so great about the fire analysis, is that it tells you what design principle should I use. I mean other than separation, but are there design principles to minimize the impact of floods on risk that you are taking into account?

MR. WACHOWIAK: Yes, and I'm not sure exactly where I got to this on the slide, but for example, one of the things that we found is that the fire code is not necessarily helpful to us in preventing floods.

It is there looking at one specific thing, and when they make the regulations for the one specific thing, they tend to affect other things in a way we don't like.

In our control building, which is mostly underground, we have to have a fire protection system. Now the equipment that is in there we have minimized -- or we have eliminated anything that needs sprinklers or anything like that, but the code still says you have to have hose stations, and the typical design is you go into your stairwells and you run your fire main through the stairwell, and you have hose stations at the various things that nobody is ever going to use.

When we looked at that, we said, well, wait a minute. If you have a break of one of these fire mains and you fill up the stairwell, you exceed the capacity of your flood doors if you put those down in there. They will open, and that will affect everything in that building. What can we do? What can we do to fix this?

Well, after some discussions with the designers, we said, well, let's not put the fire main inside the building. Let's put the fire main outside the building in its own chase, and then we just have a little two-inch stub tube that comes through the wall.

So we have effectively minimized the probability that we are going to have a large fire main break in that control building, because we were able to take our insight and move the pipe outside. So that is one of the cases where we --

DR. WALLIS: As long as the pipe breaks and not the stub connection.

MR. WACHOWIAK: The stub connection -- One, it is very short. So we were able to reduce the probability there, and that's what we did, was by reducing the frequency.

DR. WALLIS: Usually, it's a break from an inadvertent water hammer. That can pop the stub off or it could break the pipe.

MR. SIEBER: Or a seismic event.

MR. WACHOWIAK: Cause a seismic event?

MR. SIEBER: Differential movement between the pipes.

DR. WALLIS: The things that have happened in plants have usually been water hammer related, I think.

MR. WACHOWIAK: Right.

DR. WALLIS: Someone inadvertently drained the main and then turned the water on.

MR. SIEBER: Pressure is pretty low.

MR. WACHOWIAK: Some of the things that mitigate those, though, are that there are sumps there, and there are ways to get the water out. If it is a two-inch line, we can get the water out with ease. If it is a six-inch line, we would have a pretty hard time with that.

So we have tried to look at these things and make it reasonable. We are not trying to impose requirements that could never be met. So anyway -- So that is one of the ways that we have addressed some of those.

Other ways are that cables have to come from the control building or connections have to come from the control building into the reactor building.

We don't want to have a flood that can affect both of those buildings. We would like it to be confined to one or the other.

So as part of the PRA, we are specifying the minimum height that that connection can be, and we don't have water sources on site that can flood up to that level. So there are several places where we are folding what we know from the flood PRA back into the design.

MR. SIEBER: I have a question. If you look at this picture, which is on the cover, most of this is underground?

MR. WACHOWIAK: Much of that is underground.

MR. SIEBER: So how do you get the water out of a flooded compartment? You have sump pumps?

MR. WACHOWIAK: There are sump pumps.

CHAIRMAN APOSTOLAKIS: Which part is underground, Jack?

MR. SIEBER: If you look at where the steam piping comes out, right below -- It's right below where those pipes run.

MR. WACHOWIAK: The core is underground. Right?

MR. SIEBER: Most of what is on this

picture is underground. So you have to have sump pumps, which means that you are dependent in the flood scenario on providing electric power to operate the sump pumps. Otherwise, everything will flood up. Right?

MR. WACHOWIAK: Right. Now what we did in the flood PRA is we didn't -- Other than places like where we looked at that in the control building, for the reactor building we didn't take credit for the sump pumps. What we looked at was, if you had a pipe break and you put all the water from that pipe break in there, where does it go? And we failed the equipment that is associated with those levels.

Now what we did look at is, if you have flood doors -- let's say they are rated for some elevation of water, and we greatly exceed that elevation of water. We'll say that the door will open to allow it to spread to the different rooms, but we didn't take credit for the sump pumps.

MR. SIEBER: Have you analyzed to see the extent to which you can flood a room to the point where everything becomes inoperable, since you don't have gravity drains?

MR. WACHOWIAK: In the PRA our assumption is that, if the room is flooded, the equipment will fail.

MR. SIEBER: Right.

MR. WACHOWIAK: Okay. That's our assumption. In the deterministic flood analysis, they look at whether the equipment will fail due to specific things like water being sprayed on it or other things. But the deterministic flood analysis really has some different set of ground rules applied to it.

For example, a fire main can't break in that analysis. It can only leak, and there's various other things in the rules for that. So that we didn't try to take credit for it here.

CHAIRMAN APOSTOLAKIS: Let's go on.

MR. WACHOWIAK: Okay. Once again, I explained, I think, where I got the number for at power. For shutdown, we had to look around for that. We didn't really have a flood during shutdown reference that we could use.

We found some operating experience for BWRs in a NUREG, and we looked through the different flooding events and came up with a flooding probability based on those.

CHAIRMAN APOSTOLAKIS: Maybe you said it, Rick, and I missed it. But based on the general information contained in these reports, these reports presumably have flooding frequencies for existing BWRs. Correct?

MR. WACHOWIAK: Yes.

CHAIRMAN APOSTOLAKIS: These plants don't have gravity driven pools and so on. So I mean, I wonder whether these frequencies are applicable.

MR. WACHOWIAK: We don't have gravity driven pools in any of the buildings that we are looking at here either. Those are in the -- Those are all in the reactor building.

CHAIRMAN APOSTOLAKIS: Right. So I mean, shouldn't you be doing something about the flooding frequencies, since you got so much water now all over the place?

MR. WACHOWIAK: The water that we have all over the place is inside the containment. We will talk about that during shutdown. That's the time when the water can get out of the containment and into the reactor building. But in general, though, the water sources are the same as existing plants. We've got --

CHAIRMAN APOSTOLAKIS: It comes back to the question from Rich. What if these squib valves are actuated?

MR. WACHOWIAK: That's all inside the

containment.

DR. WALLIS: It's just all the water in the sump. That's all. That's all there is.

MR. SIEBER: Yes. You've got to have water in containment someplace. You can have it anywhere.

CHAIRMAN APOSTOLAKIS: All right.

MR. WACHOWIAK: But we do have other gravity driven -- or gravity draining things that we looked at. If we break off a CRD suction line inside the reactor building, our assumption is that the whole CST goes into the reactor building. Okay? That's pretty much a bounding assumption there.

MR. SIEBER: And how big is the CST for this plant?

MR. WACHOWIAK: Oh, that's a question I wasn't prepare to answer. It floods --

MR. SIEBER: A quarter million gallons?

MR. WACHOWIAK: It's a substantial flood in the reactor building. Matter of fact, it moves all the way to the --

CHAIRMAN APOSTOLAKIS: Rick, can I show my ignorance here. You guys dismissed it, you know. The water goes down the sump. Big deal. I mean, don't you have anything there? Where are the control rod drives? Or is it too high? You said yesterday it is what, several meters?

MR. WACHOWIAK: If we -- If two of the GDCS pools are drained into the lower dry well, we do know that it will flood up above the core inside the dry well.

CHAIRMAN APOSTOLAKIS: Okay. So there is no --

MR. WACHOWIAK: We might lose the fine motion control rod drives, but the hydraulic actuation of the control rods would not be affected by that.

DR. WALLIS: That's water on water.

MR. SIEBER: Yes.

MR. WACHOWIAK: So it is not discounted. It is just not specifically there yet.

CHAIRMAN APOSTOLAKIS: Oh, it will be?

MR. WACHOWIAK: Yes. I think we have to look at the spurious operation of those, and what we would do once we got to the spurious -- Maybe the answer is nothing, but it's still something that --

I hit the wrong key. There we go.

The major water sources that we -- We went through, and we looked at the water sources in the different buildings. We've got the fuel and aux. pool cooling system that is connected to various pools there.

That actually is one way that you might be able to get water from one of these pools outside of the dry well and into the reactor building, if there is a break and we turn that system on. But once again, that would be something where it would be an infrequent event, and it would be an event that was being controlled by the operators during that time, and isolable. So it's recoverable.

Reactor water cleanup and shutdown cooling: That is operating all the time. Once again, that is provided with safety related automatic isolations there. So there would be a limited water source from that.

Reactor component cooling water system: It is a closed cooling water system. It's got a limited inventory. We have taken a look at what kind of floods we can get from that, and that is included in the analysis.

Fire protection system is also a fairly large source, and in the various places we looked at what was specified, whether it was wet pipe, dry pipe, what kind of alarms and isolations we would get to see where they would be effective. But those are included in the analysis.

Feedwater system: If we have a feedwater pipe break, what does that do to these various scenarios? The feedwater pipe break outside containment -- or in the steam tunnel would not be much different from what we have seen in the rest of our analysis, but once again we are looking into what those different feedwater pipe breaks might mean to the different scenarios.

Again, the feedwater pipe break, we don't think, will cause a total loss of feedwater, because we will lose that one train. The other train comes up to speed with our aux. -- our adjustable speed drives very quickly. That is what they are designed to do, to make up for that before we would get any flooding from this feedwater system that would affect multiple trains.

In the control building, our major water source --

DR. WALLIS: What do you use for frequency of feedwater pipe breaks? Where do you get that from? Get it from a NUREG? Just count all the -- or only for BWRs? Do you just count all the PWR line breaks?

MR. WACHOWIAK: The way we did the feedwater line break was we got the number from our LOCA analysis from internal events for the feedwater.

From the NUREG we got things like fire pipe breaks and service water pipe breaks and circ water pipe breaks.

DR. WALLIS: Your feedwater design is the same as it would be for existing BWRs?

MR. WACHOWIAK: No. It is much better.

DR. WALLIS: It's much better? You know, in feedwater design you got to be careful about water hammer when you are putting cold water into the steam area. I assume that you have done it right, but who knows? I'm a bit concerned about applying sort of existing old data to a new design.

MR. WACHOWIAK: In the control building we've got a chilled water system, very limited amount of water there, potable water, small; fire protection system, and we talked about that earlier, how we arranged that so that the big pipes are outside the building.

Fuel building: Once again, we can go through these. I don't know if we need to go in detail through each of the different areas.

DR. WALLIS: No, we don't.

MR. WACHOWIAK: The turbine building here -- the circ water that we think may have already been addressed in the detailed design.

Service water building: We looked at that as a separate area, and kind of determined that that really acts like a loss of service water. So we didn't model it further.

The way we did these were we identified all these various scenarios that could potentially have floods and damage equipment. So for each given building, we applied the total flood frequency and calculated each of those three scenarios, and then we took the maximum of those three scenarios and said this is the reactor building flooding core damage frequency. We didn't try to split things apart for those different buildings.

So it is kind of a maximum type analysis where we had multiple for different -- for the same building.

Shutdown flooding scenarios: Once again we looked at different things, applied basically the same type of parameters -- or same type of method.

So what did we come up with? Internal flooding: It is not a dominant feature or factor in overall plant risk. Contribution is an order of magnitude less. So maybe you want to say this is, you know, 3.4 now or whatever.

CHAIRMAN APOSTOLAKIS: When did the events become 2.9? It was 3.1.

MR. WACHOWIAK: Rev. 0, it was 3.1.

CHAIRMAN APOSTOLAKIS: And meanwhile it was 8. The trend is right. Right? It's probably an earlier version I have.

MR. WACHOWIAK: It is.

DR. WALLIS: Now what I read -- again, I must have the earlier version. Was I --

MR. WACHOWIAK: This one went up. Right?

DR. WALLIS: Two orders of magnitude since I read it.

MR. WACHOWIAK: Okay. Now this is what happened since you read it. I'm thinking that the number that you have is probably better.

DR. WALLIS: And it might go up two orders of magnitude again.

MR. WACHOWIAK: Since you -- When you -- or we created the document that you have, we didn't recognize what the -- We did not recognize that scenario with the loss of feedwater as having the sequence of events that it did, when we did the flooding analysis early on.

Later in the -- I guess this is the PRA phase -- we recognized that change to the loss of feedwater event and, when we got to Rev. 1, we had not gone back and fed that back in.

DR. WALLIS: That overwhelms my thought, all the other events.

MR. WACHOWIAK: That's right. Just like fire, that is where the most of the flood probability comes from, is from that turbine building.

DR. WALLIS: So you got an insight from that, that maybe you should do something about the design.

MR. WACHOWIAK: And the designers, we think, may have already taken care of it for us before we even got it.

DR. WALLIS: Now I would not go into the details here, but when I looked at the event tree, I found that you had sort of had numbers that $1E^{-2}$ for drains not obstructed, just appeared, $1E^{-3}$ for water type drains intact, which means presumably someone didn't leave them open.

These numbers look to me like engineering guesses.

MR. WACHOWIAK: We have removed those from Rev. 1.

DR. WALLIS: You removed all that stuff?

MR. WACHOWIAK: Right. We just looked at what the total flooding volume would be.

DR. WALLIS: Oh, you took out all the

stuff I read.

CHAIRMAN APOSTOLAKIS: Well, it seems to me they are going to have to revisit this.

MR. WACHOWIAK: I think so, and especially after the staff reviews what we have.

CHAIRMAN APOSTOLAKIS: We understand. Is there going to be a Rev. 2?

MS. CUBBAGE: Oh, yes.

DR. WALLIS: So we shouldn't read anything until we get to Rev. 10 or something?

CHAIRMAN APOSTOLAKIS: What should we review?

MS. CUBBAGE: AP1000, which was a delta above AP600. In AP1000 there are 15 revisions of the design control document and eight or 10 revs of the PRA.

DR. WALLIS: So what do we read?

CHAIRMAN APOSTOLAKIS: Well, there is an issue here, because we cannot have 10 supplementary meetings.

MS. CUBBAGE: This is an introductory meeting and --

CHAIRMAN APOSTOLAKIS: I understand that, but --

MS. CUBBAGE: -- when we get to the point of the staff has completed their evaluation, that is when we are asking for your --

DR. WALLIS: Well, but then why did you give us something to read, assuming we wouldn't read it? We read it intelligently.

MS. CUBBAGE: If we hadn't given you something to read, then you would have --

DR. WALLIS: For the moment, we are asking about the details.

CHAIRMAN APOSTOLAKIS: But they are sure it is going to be a BWR. Right? Well, let me ask something I have here. When should the subcommittee meet again? I mean, we were thinking originally late September/early October. Now Rev. 1 will be ready by then. Right?

MS. CUBBAGE: We will have all of Rev. 1 of the PRA within two weeks.

CHAIRMAN APOSTOLAKIS: No. We don't need it in two weeks. The question is: The document we will be reviewing in October is subject to more changes. I mean, should we postpone the subcommittee meeting then?

MS. CUBBAGE: I think it is beneficial to have the committee identify issues as early as possible, but there is also the risk of wasting time with cycling through. So I think we will have to take a look at our review schedule for this area, see when it is convenient and the staff has maybe developed their FTR with open item input.

CHAIRMAN APOSTOLAKIS: Yes, but on the other hand, Rick also said yesterday that he is not in a position to change the PRA anytime we find something. I mean, we have to do our reviews in a relatively timely manner. Right?

MR. WACHOWIAK: Yes. I would like to have still in September the discussion on the methods for HRA and the methods for common cause, things that we think methodologically that you may want to see different in the PRA.

MS. CUBBAGE: Right.

MR. WACHOWIAK: But discussing which particular sequence happens to be the dominant sequence today may not be the most productive thing.

DR. WALLIS: I find a difficulty with that, because very often you get credibility by doing the details right. The devil often is in the details, and if your details keep changing or just being whisked away, then what do we review? How do you gain -- You are not going to gain credibility with an overview of stuff. We've got to be able to dig into some examples in enough detail to be sure you've done a good job, and if those examples keep changing all the time, what are we going to review?

MS. CUBBAGE: Graham, I think -- Rick, correct me if I am wrong, but we are hoping that the delta from Rev. 0 to Rev. 1 will be the most significant one, and the increment will be smaller as we go on. And if now, we've got a big problem.

DR. WALLIS: Well, someday we are going to review something and then say yes or no, and we can't review it and you say, oh, but it's changed. That's no good. We are going to say no in that case. You will bring us something, and we are going to say yes or no. We are going to say yes or no on what we see, not on something that is going to be changed. Someday we are going to do that.

CHAIRMAN APOSTOLAKIS: I think what they are implying is that we may have to meet again more than once. I thought we were going to meet only once.

MS. CUBBAGE: I think we need an interim meeting to talk about methodologies, I think, would be useful. But when we get down to the point where the staff has an SER with open items, there will be the details and PRA that that is based on. So we will be looking to get feedback in a more concrete form at that time.

CHAIRMAN APOSTOLAKIS: Okay. So we will probably have more than one supplementary meeting. So we will schedule one for sometime September/October.

DR. WALLIS: Well, I guess when you've got a committee letter, a committee letter will probably be based on something that is not going to whimsically change.

CHAIRMAN APOSTOLAKIS: That will be again informational.

DR. BONACA: But it seems to me that, you know, my expectation at this stage was, you know, how did the PRA lead you to certain things, and here we are interactively working design.

DR. WALLIS: That's good.

DR. BONACA: In October, it will be interesting to know -- to have some perspective of how you -- I think you gave it to us already today, but in part you just came in and you described the results of a configuration you have analyzed which is still up there. It will be interesting to see how you went into that, particularly with the design process, to get these results.

Yes, you did some of that today and yesterday, but --

DR. ARMIJO: I don't think that the details are changing whimsically at all. I believe it is part of the process. As they go through, they learn more. They make some changes, and I think it's all part of the process for where the design stands right now, and I don't think there is anything whimsical about it.

DR. WALLIS: When the numbers are changed by over two orders of magnitude -- there is a new event appears which wasn't there before. this seems to me a significant change, whether it is whimsical or not. It's something that might appear whimsical, since we didn't know it was going to happen.

DR. ARMIJO: But I would -- The fact that they have a few significant changes doesn't surprise me at this stage of the design and the stage of going through it.

CHAIRMAN APOSTOLAKIS: I think another way of looking at it is that we got involved too early, but we are learning.

MS. CUBBAGE: Well, I don't believe -- I think in the near future I need to meet with Eric and all of the other ACRS staff members and plot out more of a complete plan for interaction.

Just as a matter of reference, on AP600

there were six full Committee meetings, 37 subcommittee meetings.

CHAIRMAN APOSTOLAKIS: Yes, but 36 of them were thermodynamics.

MS. CUBBAGE: And AP1000, 8 full committee, nine sub, again heavily weighted on the thermal hydraulics. So --

CHAIRMAN APOSTOLAKIS: No, I don't mind having more subcommittee meetings, because it really helps us.

DR. WALLIS: Well, we are going to apply thermal hydraulic standards to the PRA now.

MS. CUBBAGE: Oh, we are looking at it.

DR. WALLIS: When the things change by two orders of magnitude from one day to another --

MS. WACHOWIAK: I also want to say, yes, once again we didn't change -- we are not changing things whimsically. It's like they were saying. As we learn more, we incorporate it in. We are hoping that we won't see anymore two order of magnitude increases on anything. However, remember, we are playing around down here in the 10^{-8}-10^{-10} range, and you know, you can hiccough and you can move to 10^{-10}.

CHAIRMAN APOSTOLAKIS: I repeat what I said yesterday. The age of the earth's crust is 3^{10},

10^9 years. So you know, maybe we should stop a little bit and --

DR. WALLIS: If you were a creationist, you would say it was a lot less than that.

DR. ARMIJO: Just a quick question. Is there a chance as the design progresses that that 3 x 10^{-9} might flip back to the 10^{-11}?

MR. WACHOWIAK: What I have seen is it is very likely that that will happen. As they added detail to the turbine building, it looks like -- for other reasons than the PRA, it looks like they have addressed the particular circ water pipe break that caused us to get that two order magnitude change.

So that one, I may expect to go down.

CHAIRMAN APOSTOLAKIS: Rick, what is wrong with having the external events contribute to core damage frequency? The attitude here, it seems to me: No, we must dismiss that. I don't understand that. You are down to the 3 times 10^{-8} or 7, whatever it is. I don't see any problem saying, yes, and 10 percent, 30 percent of that is due to fire. Why go out of your way to dismiss those?

MR. WACHOWIAK: The main reason is that the analysis isn't really on the same footing as what we have done with the internal events.

CHAIRMAN APOSTOLAKIS: Well, if you do the bounding analysis, then it's not.

MR. WACHOWIAK: Right. So that -- What we are trying to avoid is, if we have these numbers close to each other, then some people may tend to forget that this is our best estimate number, albeit with uncertainties, but this is a bounding number, and this number really isn't 4 times 10^{-9}. It is something different from that.

Then when we go back in, and if we just say, well, then let's put it altogether in one big model and solve everything in our one big model like some plants have done, now you get a different -- maybe a different maintenance rule, risk significant list than if you had kept them separate, or maybe you get a different --

CHAIRMAN APOSTOLAKIS: But they do take into account these things when they establish the maintenance rule, the criteria and so on.

MR. WACHOWIAK: Right.

CHAIRMAN APOSTOLAKIS: So I don't think that is a problem. In fact, I remember even in the case of special treatment requirements, they kept external events separate, see what kinds of insights we can get from those.

MR. WACHOWIAK: That's right. But then we run into the problems with having to have all the expert panels and having to have the separate rules and move things into one bin or the other. So we think that it might be cleaner if could just show that it is not going to be --

CHAIRMAN APOSTOLAKIS: I understand that, but I mean, thinking of a little higher plane, you are down to such incredibly low numbers, and to say that the events that cause dependencies are dismissed, and then there are other failures that dominate, it doesn't gel. Right? I mean, you are down to very insignificant --

DR. WALLIS: What is most likely to happen in terms of event is something that isn't in this picture at all.

CHAIRMAN APOSTOLAKIS: Oh, no. This does not include acts of God.

DR. WALLIS: No, it doesn't include something like the Davis-Besse. If anything does happen, it is going to be probably of that type.

CHAIRMAN APOSTOLAKIS: But as Rick said -- you put it very nicely yesterday, that you are addressing in this design things that have happened before, we can think of. You are not getting into things that are outside. I mean, whether the safety culture of the plant is good or not is way beyond your capability to control it. Right?

MR. WACHOWIAK: At least now, yes.

CHAIRMAN APOSTOLAKIS: Anyway, are you done?

MR. WACHOWIAK: Quickly, I think we have talked about all these different things here at one point or another. From the flooding, we looked at layout of where things should be.

Safety redundancy and separation: We want to try to move things around. Just like in fire, we used our best principles to put things where the floods won't interact so much between different systems.

DR. WALLIS: Someday we are going to get to the point where you are going to explain how you predict the probability of a full drain getting blocked. You are going to get to that detail someday?

MR. WACHOWIAK: No. I don't think we are going to include the floor drains.

DR. WALLIS: Well, it is a 10^{-2} event. According to you, you could easily get a factor of 10 out of that one, and you get a few more factors of 10, then things stop being so insignificant.

MR. SIEBER: I think the floor drains are important.

DR. DENNING: Well, I guess how you treat them. Are you saying that you will assume that the drains don't work and that you will plug them stably or are you assuming that they always work?

DR. WALLIS: They have a 10^{-2}.

MR. WACHOWIAK: In Revision 1 we have assumed that they don't work.

DR. DENNING: They don't work? So it is a conservative assumption.

MR. WACHOWIAK: It's conservative.

DR. DENNING: In substance.

MR. WACHOWIAK: Yes. The only place where it would be nonconservative is if we have a floor drain here where the flood is in this room, and there is nothing bad in that room, but it can go down into the room where there is something that could be a problem. We looked at those. In that case, the floor drain always works.

MR. SIEBER: The drains communicate with one another, too.

MR. WACHOWIAK: That's right. So I believe we've got backflow devices and things.

MR. SIEBER: That's an opportunity plug.

Any device you put the drain is an opportunity plug.

MR. WACHOWIAK: I will move on to the last couple of slides here before, I think, we might be at a break.

The high wind risk is basically our tornado analysis. We treat it as a loss of preferred power with no recovery in the first 24 hours, and we also assume that the condensate storage tank would fail. So that wouldn't be there as a water source.

Initiating frequency, though, turns out to be much, much lower than what we have already assumed in the loss of preferred power.

CHAIRMAN APOSTOLAKIS: Why this assumption, Rick?

MR. WACHOWIAK: Why? Because the tank itself is subject to tornado missiles.

CHAIRMAN APOSTOLAKIS: It's outside?

MR. WACHOWIAK: It's outside, and we could potentially drain that tank.

We treat it this way. When we run through the calculation for it, though, it turned out to be rather small. We will be readdressing that again when we update through, but we think it is still going to be small. the initiating frequency is not --

DR. WALLIS: It makes a bit of difference where you put the plant, doesn't it? High wind risks are certainly much greater in certain parts of the country than others.

MR. WACHOWIAK: High wind or tornado?

DR. WALLIS: Or both.

MR. WACHOWIAK: There's little difference. The highest rate winds are already built into the loss of preferred power scenario. So that's already in there. But if we are talking about tornadoes, things that can have this other effect on top of it, those tend to be a much lower probability than a loss of off-site power, which is in the one in five years.

DR. WALLIS: It makes a difference where you put the plant. For a plant in Oklahoma, it is very different from putting it in Alaska.

DR. DENNING: For your initiator frequency, what was your assumption on the tornado?

DR. WACHOWIAK: I'd have to look at that. I don't remember. It probably came from URD, which was drawn from industry averages. I would be surprised if it came from anywhere other than the URD.

MR. SIEBER: You can actually construct a plant so that it won't receive damage.

DR. BONACA: Why is the plant designed to be so much underground?

MR. WACHOWIAK: Why is it designed to be underground?

DR. BONACA: Yes.

MR. SIEBER: It's a good idea. Don't change that.

MR. WACHOWIAK: There may be several reasons. I'm not sure that I know.

MR. SIEBER: It's easier to build.

MR. WACHOWIAK: There are probably many thoughts that went into that. The PRA was not one of them.

DR. DENNING: Continue.

MR. WACHOWIAK: Okay. We did do a seismic margins analysis to address the capability of the safety systems. Now this is safety systems only where we've looked here. We looked at the design fragility for these systems. Once again, those things would have to be confirmed when the plant was built.

We have an entry for the sequence of events. It looks kind of like a loss of off-site power type of event. We assigned the safety systems onto there. Non-safety systems, basically, are assumed to fail in this scenario, and then we looked at along every success path -- or along every path in the sequence what has to fail -- what do we have in each of those sequences that can prevent the core from being damaged and the minimum -- the maximum fragility for that -- for anything in the path is the fragility for the sequence, and then the minimum fragility for all the sequences, the fragility for the plant. It is not an overly detailed or overly complicated thing.

It turns out that all the sequences are at least two times the safe shutdown earthquake. I think it is a little higher than that, 2-point-something. We looked at it for both full power and shutdown, and because of this, we are asserting that it is unlikely that seismic will be a vulnerability.

Now will that mean that -- What will it mean for overall risk numbers if we ever do a seismic PRA? That's uncertain at this point. We can't say.

MR. SIEBER: Well, it gets some insights. It's all you can do.

MR. WACHOWIAK: We can probably get insights.

DR. DENNING: So you have no intent to do seismic -- to take a couple of sites and to do a real seismic PRA? Because I think that you are headed toward -- When we wind up with an operating plant, then this is the risk dominant for many plants. This is dominaturist. Am I wrong? Because there is implicit risk associated with the seismic margins analysis that is more like the traditional risks we have had.

Now here you are designing a plant to be a 10^{-7}, 10^{08} plant, but you are using more the historical seismic logic here. Am I wrong?

MR. WACHOWIAK: I wouldn't say that you are wrong. At this point, though, from my understanding of DCD and what goes into a COL application, PRA is at seismic margins would be what we have.

CHAIRMAN APOSTOLAKIS: I still have a problem -- what I said earlier. You have a plan that has internally been core analysis frequency way down there, 10^{-6}, and the major common cause failures have dismissed as being insignificant compared to this insignificant number. I have a problem with understanding that.

I mean, you could have a strong earthquake. It is going to shake the whole thing, and yet we are saying, oh, no, no, the sequence -- and also preferred power is still dominating, and that involves random failures. That's a little hard to digest. But maybe at another subcommittee meeting we can go more deeply into it.

You are already way down there at 10^{-6}, and you are saying there is a strong earthquake, and that is insignificant compared to the random failure of components. How can that be? There is a reason why earthquakes and fires are usually significant contributors to risk for existing LWRs. The reason is they are contributing events, and the plants are so redundant that, unless you have these big sources of dependency, you don't see much action. But here it seems to be the other way. I am still bothered.

I don't have a specific comment that says, hey, guys, here you really overdid it, but I sure would like to have a subcommittee meeting going into this more carefully, and see whether you -- Maybe your results are fine. I don't know, but geez, it just doesn't make sense to me, you know, without getting into the details.

I don't know how all the other members feel about it.

DR. DENNING: Well, the fire I understand. Fire is a different animal in that you really can design a plant with true separation. Seismic is a different animal.

CHAIRMAN APOSTOLAKIS: It's just shaking the whole thing.

MS. CUBBAGE: You are talking about an earthquake of a lower probability than the SSE, which could be dominant, because --

CHAIRMAN APOSTOLAKIS: Yes, because we are already down to 10^{-6}.

MS. CUBBAGE: You could have a 10^{-8} earthquake that would be different than anything they have analyzed.

CHAIRMAN APOSTOLAKIS: Yes. Just kills everything.

MS. CUBBAGE: So something like that could be dominant.

CHAIRMAN APOSTOLAKIS: It could be. Well, it doesn't have to be the dominant in the sense that it would come out 10^{-7}, but to actually say that it's dismissed, compared to $3\text{-}10^{-8}$ -- I mean, wow.

DR. DENNING: I'm not sure it's exactly said that it was. But that's okay.

CHAIRMAN APOSTOLAKIS: Are you there, Rick?

MR. WACHOWIAK: This one, I did not say that it was dismissed. I said we don't expect it to be a vulnerability. Now how you define a vulnerability is in the details.

CHAIRMAN APOSTOLAKIS: We are very clever.

MR. WACHOWIAK: I think that's it for break time.

CHAIRMAN APOSTOLAKIS: We still have your shutdown management.

MR. WACHOWIAK: That will be short.

CHAIRMAN APOSTOLAKIS: Because members will start disappearing -- In fact, everybody will leave at twelve. All right?

DR. DENNING: Well, Graham is actually about to leave. Is that true, Graham?

CHAIRMAN APOSTOLAKIS: Graham is leaving a little earlier.

DR. WALLIS: After the break.

CHAIRMAN APOSTOLAKIS: After the break? You are here for the break?

DR. DENNING: The alternative would be to do the shutdown now, and then Graham can take off.

CHAIRMAN APOSTOLAKIS: You guys, you are asking me to violate my principles.

DR. WALLIS: It's supposed to be at 10:30. the break is on the schedule for 10:30.

(Whereupon, the foregoing matter went off the record at 10:03 a.m. and went back on the record at 10:17 a.m.)

CHAIRMAN APOSTOLAKIS: The next

presentation is on the shutdown events, and I noticed that you never use the word risk assessment. You always say risk management. Is that a conscious decision or it just happened?

MR. WACHOWIAK: Yes, it is. It's a conscious decision.

CHAIRMAN APOSTOLAKIS: It's a conscious decision. Okay.

MR. WACHOWIAK: In the process where we are in the design, at least we have the great opportunity that we can manage the risk.

MR. SIEBER: So you haven't built anything yet. So you can change the plant to manage the risk.

MR. WACHOWIAK: David has a couple of answers to some questions that came up previously. Been doing some research here.

MR. HINDS: This is David Hinds with GE. Just a couple of quick answers to the questions that came up, at least a couple of them that we had to table. In fact, one of them is an actual correction.

The question related to grade elevation and what is below grade elevation. If you look at those cutaways -- I think they are on your handouts -- the grade elevation is approximately equal to the bottom of the suppression pool, similar to the bottom of the core. So the bottom of the suppression pool is equivalent with grade elevation, as per the plan.

Now there will be slight -- potentially slight differences on site specifics, but that's the approximate grade elevation right now, at the bottom of the suppression pool. Okay.

Additionally -- it's actually a correction from one of the questions that was asked, and we made a quick answer to, and I need to correct a little bit, in that it wasn't exactly correct. We have also a question that you had related to quickly do we depressurize when we get an actuation signal or SRD.

We do not depressurize that quickly. Our design is that, if we get an actuation signal to depressurize, there is a time sequence such that all valves do not open immediately. First the SRVs, the ADS valves -- the SRVs that are ADS valves, five of them open immediately, and then five additional ones open 10 seconds later, and then 50 seconds within the event three of the depressurization valves will open.

So there is a time delay such that the initial depressurization begins with SRVs to the suppression pool, and then the complete depressurization begins with the DPVs, depressurization valves, 50 seconds into the event.

It begins with three opening, and then a sequence continues on with two more opening at 100 seconds, two more opening at 150 and one more opening at 200, eight total DPVs, but they are staggered in 50-second increments to bring pressure down totally.

I looked at one of the loss of feedwater sequence, and at approximately 280 seconds into the event pressure is low enough for the gravity driven system to eject the vessel. So we were incorrect on our timing sequence.

CHAIRMAN APOSTOLAKIS: Okay.

MR. HINDS: Thank you.

MR. WACHOWIAK: Okay. I want to talk about shutdown. The scope of our shutdown analysis -- and once again, this is in Rev. 1. You have Rev. 0 now. We don't have all of this in there. In Rev. 0 it's there.

Internal events, external events: We talked about some of the external events earlier. Seismic margins we talked about.

The scope is that we included Mode 5, which is called Shutdown, Mode 6 which is refueling. there are two modes that -- and the power operation is clearly Mode 1. So what happens to Modes 3 and 4, Hot Shutdown and Safe Shutdown?

We have taken a look at those two modes and decided that they really are enveloped by what we did in the Mode 1 PRA, and didn't elaborate on these in detail anymore.

We will probably, before we are completely done, readdress that to look at specific things like what is the actual sequence during a shutdown for refueling, and also our other colleagues are working on tech specs, and they have a question for us about end stage: Should you have to go to cold shutdown all the time? I think we are going to have to look at that to answer some of their questions.

Timing of when those questions will be answered, I'm just not sure. But our scope now is Mode 5, Cold Shutdown; Mode 6, Refueling, and Mode 6 is really split into with the cavity flooded and the cavity unflooded, different responses there.

Pretty much you have the same level of detail in the shutdown model as we did in the power operation model. We've got event trees. The system models are nearly the same with just some tweaks on them. So it's the same kind of level of detail.

I kind of went through which events we are going to look at. Manual shutdown -- there is an event for manual shutdown there. LOCAs, we only considered in Mode 6. Once again, we are saying that the Mode 5 LOCAs are probably enveloped by or bounded by what we did in the at-power scenarios.

Now these other ones, loss of power, loss of shutdown cooling, fires and floods -- we didn't look at those in Mode 6 with the reactor cavity flooded. The main reason is before -- if we are flooded, we've got 72 hours or more before we have to regain the shutdown cooling function.

So with that long period of time, something can be done, and from the data that we have seen from plants, existing plants, three days certainly would be an adequate amount of time to do something about recovering that function.

One of the things that we did differently for the three models during the shutdown are in the area of the maintenance activities. What did we assume different from the configuration of the plant for the Mode 1 operation?

Multiple pumps and trains of feedwater and condensate can be unavailable when we are in shutdown, and that is factored in for all the modes of the shutdown evaluations.

A question came up: What about flood and fire barriers? Could any of those be disabled during shutdown? Typically, we see some of that in the existing plants, and how do we want to address that?

So as part of our shutdown external events analysis, we looked at the effect of having those barriers disabled. In Mode 6 we assumed that isolation condensers have been taken out of service for maintenance.

We allow one GDCS pool to be out of service for maintenance of its valves during Mode 6. PCCS is unavailable in Mode 6, mainly because the containment is open at that point, and it wouldn't do us any good. SRVs and DPVs are assumed to be undergoing maintenance in Mode 6. Therefore, they will be -- Well, the lines to those will probably be blocked off after the event -- or after the flood-up occurs.

Now we did look at recovery actions in Mode 6. Shutdown events tend to move slower than the power events, mainly because we are starting from a lower decay heat level, got more time to recover the initiating event.

So what we looked at were industry data on loss of shutdown cooling events, loss of offsite power events, loss of service water events, and created a nonrecovery curve similar to what's been published for loss of offsite power for these other systems, and applied a five-hour recovery to our initiating events.

So we will just right now jump over to the results. The manual shutdown is very low. Loss of decay heat removal is very low, and we looked into whether adding that recovery factor is what is driving this; because if the recovery factor is driving it, then I'm not sure we want to -- We will at least want to put that into our sensitivity analysis, but that is not doing it.

It would only come up to something times 10^{-12} if we removed the recovery factor. So that is not what is driving that there. I think it is just the overall time to respond.

Loss of service water is also low. Loss of preferred power is getting into the -- or we are starting to see some things in the scenario, and LOCAs tend to be the highest. We will talk about the LOCAs. It is two specific LOCA scenarios that are the dominant factors here.

DR. KRESS: Is there something on how long you will be in shutdown mode?

MR. WACHOWIAK: Yes. These are all weighted for the two-year refueling cycle with the refueling outage link that we have stated to the customers that they would have. So it is weighted to that -- another reason why it is low.

In our containment we got all these pools of water here. For now, assume that there is a head up on top of that. But in the shutdown events, we still can flood the reactor up from these other pools. Now the breaks that are giving us most of the risk in shutdown are the breaks that would occur in instrument lines and the reactor water cleanup lines down low on the vessel, these lines that come out underneath the core.

If those lines break, then all the water we've got in here comes out and, if it gets down too low, it shuts off shutdown cooling. We lose decay heat. If the lower drywell is intact or these hatches aren't open, we've got enough water in the GDCS pools and every place else to keep this all flooded up so that the decay heat removal can keep on operating. That is not a problem, if we've got this cup here to contain all the water.

Certainly, if we've got the refueling pool open up on top, there is enough water there without activating any of the GDCS pools, once again to keep the core covered and keep the shutdown cooling system operating.

The problem with that is one of the things we do in the refueling is get under here to maintain the control rod drive mechanisms that are in here. Historically, what plants do is they will open up these hatches. They will run cables through there and airhoses through there and all sorts of things through that, and if this door is open, it doesn't matter what happens with the rest of these things.

The water comes out, goes out through the reactor building, floods up everything in the reactor building, and there is not enough left there for the core, even to potentially affect the equipment that could -- like FAPCS that we could be using to pump water back in, that magnitude of flood would affect the FAPCS. So we really don't have any recovery from that event other than getting out and closing the doors.

DR. WALLIS: With the water pouring through?

MR. WACHOWIAK: Well, yes, and depending on the size, it's anywhere from about an hour and a half to about three hours before the water starts pouring out. So anybody working in there is going to recognize that this is happening. It is going to be a dramatic event for them, and they are going to be out, and people will know about it, and you could get the hatch back on.

The problem is all of this stuff that is running through the doors that you have to disconnect before you can get the hatch back on.

DR. WALLIS: Well, they may have to walk through some hot water and steam to get to the door.

MR. WACHOWIAK: This would be refueling. So it would be warm water. Like I said, it would be a dramatic event for anyone who is in there.

In our number that we have there, we have taken credit for the operators and the crew that's out there being able to get that door closed in some --

DR. WALLIS: Does the water come down in a way that it would cascade down past the hatch or is it somewhere else? If there is a break, is it going to come --

MR. WACHOWIAK: Oh, is it going to come out here? Is it going to come out there?

DR. WALLIS: Near the hatch. Is it going to impede the sort of action of shutting the hatch?

MR. WACHOWIAK: We don't know that right now, because those pipes have not necessarily been routed. So we wouldn't know. But once again, that's a good question, and we have a new insight now that we can write down and say don't put the pipes over there so that it would cascade.

So that is an issue that goes into that. And here is one of our examples of a PRA as a design tool in process. We've noticed that we could live with a 10^{-9} CDF -- an addition to CDF 10^{-9} CDF, but you know, the thing is that is one of these things where it's a containment bypass also, and do we want to live with a 10^{-9} containment bypass? I don't think that that's someplace where we are going to want to end up.

So we are looking at various options. What do we do -- I think I talked about that. What do we do to address this? And we've got several things, brainstorming ideas that we are running past the designer, and we are coming up with an optimized way of making the -- either making it so that that hatch doesn't have to be open. If it's already closed, what do you about the people inside? There's also sorts of different considerations there.

Well, and there's ways to address that, too. That's not just a given there, but there's things to do with the hatch. There's things to do with maybe providing service penetrations or maybe a special hatch that goes on during outage that has the service penetrations. We don't really know yet. We are in the process of determining what we can do.

DR. WALLIS: Don't you have lines going through the hatch? You have compressed air or something going through there?

MR. WACHOWIAK: That's the problem that we have.

DR. WALLIS: Push it out of the way to close the hatch.

MR. WACHOWIAK: That's what we are trying to do.

DR. WALLIS: Now did you say before there is no recovery from this and that the water is draining out, and it's gone into the reactor building. There is no way to recovery cooling, is there? I mean, you are going to eventually drain the core.

MR. WACHOWIAK: Eventually, you are going to drain the core.

DR. WALLIS: There is no recovery.

MR. WACHOWIAK: We don't like those kind of events.

DR. WALLIS: No, I don't like it either.

MR. WACHOWIAK: You can stop it.

MR. SIEBER: You can stop the event, but like closing the doors.

MR. WACHOWIAK: But that's where the

question comes in. At what point does the flooding in the reactor building prevent you from keeping on trying to close that door. How long does it take to close the door? Is there some level of water in the drywell that you can't get the door back on anymore? All those things need to be --

DR. WALLIS: Or there is some equipment blocking it in some way.

MR. WACHOWIAK: I think the equipment we could probably deal with procedures, but once again it is something that I don't know that we want to have hanging over our maintenance and operators' heads there. I think we would prefer a more elegant solution to this.

As I said, the design team is looking into what can happen or what we can do in a reasonable manner that provides not necessarily a pressure boundary for containment there anymore but a water tight boundary that we can use so that we can flood up and provide our thing. So this is a PRA insight to the design in progress.

MR. MAYNARD: Well, you could also at least clearly limit it to smaller breaks.

MR. WACHOWIAK: It is limited to smaller breaks.

MR. MAYNARD: You could also have pumps down there.

MR. WACHOWIAK: Those are things that in the consideration mix. One of the problems with the pumps down here is, when we are flooded all the way up to the reactor well, we've got 40 meters of water head on top of that hole, and you get quite a bit of water out through a three-inch line with 40 meters of water up on top of it. But we have in the consideration is maybe we bring in some big portable sump pumps that deal with that.

MR. SIEBER: Well, you've got to be able to pump it back up to the top.

MR. WACHOWIAK: Right. So there are a whole myriad of things that we are looking at to address this, and we are going to try to come to the best solution for both certifying the design, because we want to do that, and for our customers who have to operate this plant.

DR. WALLIS: Well, this is a LOCA. You don't go into that hole when the pressure is high, do you?

MR. WACHOWIAK: It's not a high -- It's not a LOCA that's caused by pressure in the system. It is a LOCA that mainly is kind of influenced by people being down there.

DR. WALLIS: They cause the break?

MR. WACHOWIAK: Depends on where it is. There are some valves in there that the break is far enough away in the line that it can be isolated there.

MR. MAYNARD: You could have some type of maintenance activity going on in there that breaks the pipe.

MR. WACHOWIAK: There's all sorts of things there. Hopefully, when we start building this, we won't be doing those kind of things.

MR. SIEBER: Well, the service penetration is a good idea, but I don't think putting it in the hatch is a good idea.

MR. MAYNARD: Does the containment -- the equipment hatch up above, does it have a way to close in a fairly rapid manner? I take it, you have some type of equipment hatch up.

MR. WACHOWIAK: We have one up on top and one down below.

MR. MAYNARD: If you needed to close off containment like in Mode 5 when people have it open, bringing stuff in and out, if you had a LOCA it is at a point. The idea is to be able to get that hatch closed. Do you put any special mechanisms in for closing that hatch?

MR. WACHOWIAK: For the upper drywell? I'm not aware of any scenarios where we would have to close the upper drywell hatch.

DR. ARMIJO: Is this a unique problem with this design? I mean, has this issue been in front of BWRs before?

MR. WACHOWIAK: It's possible that it has been, but if we look at, let's say, a Mark I plant, the hatch is down low, but the suppression pool is down lower. When you start doing this draining, you've got a long time to fill up the suppression pool before you get to a point where you would have to close the hatch. Also, the ECCS pumps take a suction off that suppression pool and pump it back into the reactor.

So this is -- I think this is something that is unique to moving the suppression pool up higher with respect to the reactor. So it's a challenge, and it is -- The main challenge is trying to figure out what is the best option for the customer, because we know we can do it somehow. We just haven't figured out how yet.

CHAIRMAN APOSTOLAKIS: Let's move on.

MR. WACHOWIAK: Okay. The next thing I

want to bring up is that, based on what we have seen so far in our fire analysis, we are not going to be able to say that fire barriers can be uncontrolled during outages. During the outages, we are going to have to do something with the fire barriers.

We are either going to have to specify that you don't break them or, if you do, you apply appropriate compensatory measures so that the fire barriers remain reliable. So that was a good thing that was brought up to take a look at during outages, and I think it is something that is going to bear out.

There is a possibility that, when we get the detailed routing and layout and fire modeling done, we might be able to relax that, but I don't see that happening anytime during this certification phase. So we will be adding that into our operation and maintenance requirements.

Once again, on shutdown it is an iterative process with the design still going forward. Some of the things that -- details that we are dealing with could affect the dominant sequence. Well, they will. We want them to affect the dominant sequence. We don't think there is much left that is going to affect the other sequences and bring them up, but we are continuing to look at that.

As I said before, fire and flood for shutdown is still under development. Flood, we pretty well have nailed down to where we are going to come out for the DCD. Fire, we still have a little bit of work yet to do to get that to the place where we are comfortable releasing it.

Now on my last item -- Is there any shutdown questions yet? I'll just move right along into the last one.

We saw this earlier yesterday. ESBWR risk management program: We support the goals that we need for this DCD. I think we've got the right scope for what we are trying to do here. We believe we have enhanced the defense in depth of the plant, and through some of the various examples you can see we are using it as a design tool to address things that we are discovering and things that are, in some cases, unique.

We are going to continue to modify this thing all the way up to and past plant operation, and this question of where does it fall into whose hands for approval -- I can't answer that, but I do know that we are -- Our goal is to keep advancing this PRA to be state of the art by the time we are operating as a plant.

A couple of observations that I have. ESBWR, once again: Robust design; results in a low CDF based on the things that we know about; but as we have been talking for most of this morning, we are testing the limits of what we can do with the techniques that we have here.

DR. WALLIS: By the way, while you were talking about what happens underneath the vessel during shutdown, and if these squib valves -- or you break the deluge system when there are people standing around under there, they get a big surprise, too.

MR. WACHOWIAK: There's maintenance block valves. Those would be closed.

DR. WALLIS: Those were going to be all blocked off, so that that couldn't happen?

MR. WACHOWIAK: That's right.

DR. WALLIS: Okay, thank you.

MR. WACHOWIAK: We looked at that one.

The unknowns may be as important as the knowns in some of these cases. I think we've talked about that. So what we are addressing in this PRA is the things that we know about and the things that we can know about.

Some screening methods that -- and we've talked about this with the fire stuff. It doesn't seem to be as effective here. Things that we could -- If we could show a 10^{-8} sequence using five and a building in an existing plant, we would say, okay, we are done, that's as good as we can get.

Here, that's not quite what we can do, and it looks like the thresholds to screen things end up being so low that the unknowns are affecting what we can get to with these thresholds. So that is a difficult question.

The other thing that is coming up in the use in the rest of the approval process for this DCD of the PRA -- and here it is looking at risk significant items for the D-RAP and looking at how we do things in the tech specs. Using a relative risk ranking approach and the thresholds that have been used for existing plants can be a problem, I think, for us with the CDF the way we are and with some of the things that we are doing in this analysis.

The risk achievement worth value of 2, which has been used for maintenance rule things in the past, gets just about everything in this plant; because everything has some sort of a contribution to keeping the risk low.

We've got the function. It's passive function surrounding by the active function with the support systems, and those things are duplicated over and over throughout -- and all the event trees look fairly much the same. The same equipment is providing things there, and we tend to have everything contributing here, at least somewhat, to risk.

An increase by a factor of 2 on 10^{-8} is not the same thing as an increase by a factor of 2 on a 10^{-5}. So that is one of the things there, and so in moving toward passive plants, I am wondering about the relative risk ranking that has been used in the past and how applicable it is for the future.

CHAIRMAN APOSTOLAKIS: Well, if the utility decides to make a risk informed change to the plant after it is built, and they use Regulatory Guide 1174 -- I mean, geez, even the 10^{-6} would overwhelm everything else.

DR. SHACK: They could build 100 new units.

MR. SIEBER: You can't make any changes once you get low enough.

CHAIRMAN APOSTOLAKIS: The changes there would be even down to the 10^{-7} or 8 range. So we have to change the figure in the Regulatory Guide.

MR. WACHOWIAK: So that is one of these things that it's out there on the horizon or just past the horizon that we ought to be thinking about when we move into approving those other phases of the DCD.

CHAIRMAN APOSTOLAKIS: So the main reason why your CDF is so low is because it's a passive plant.

MR. WACHOWIAK: Because it's a passive backed up by active backed up by more active.

DR. WALLIS: Just by the passive by itself -- You don't get that by the passive by itself.

CHAIRMAN APOSTOLAKIS: You get 10^{-5}.

DR. WALLIS: That's right.

CHAIRMAN APOSTOLAKIS: You did it, right? You did the focused PRA.

MR. WACHOWIAK: Right.

CHAIRMAN APOSTOLAKIS: Okay. Anything else? You done?

MR. WACHOWIAK: I just want to make sure I put this page back up again. The words are there. We think that, when we compare to other plants using the same methods and the same techniques, we've provided the best level of safety that we've seen so far.

DR. WALLIS: Not just for the old fellows.

MR. WACHOWIAK: So the next ones will come in after us and say something else. Now it's my turn.

DR. WALLIS: That's been very useful. I thought it was a good overview of the PRA, and we will examine the details, I guess, at some future date. Very useful.

MR. WACHOWIAK: Thank you.

DR. WALLIS: Thank you.

CHAIRMAN APOSTOLAKIS: So who is next? Amy?

MS. CUBBAGE: Yes, and we are a few minutes ahead of schedule, and I will review these quickly.

CHAIRMAN APOSTOLAKIS: Yes, but it's better if you stood up.

MS. CUBBAGE: Okay. I'm getting the computer ready here. I'd like to ask our review team: Bob Palla, Marie Pohida, and Nick Saltos, to come and join me up here in case you have any specific questions about these RAIs.

I know that you have received a copy of the RAI letter itself which goes into all these questions in more detail. So this is just intended to provide a quick overview of what questions the staff asked in their preliminary round of questions when the application was first received.

We have received responses to some of

these questions, but we are waiting for the final Revision 1 to address all of them.

The first 10 questions were Bob Palla's questions. They relate to severe accident design features and primarily Level 2 RPA. The first question was regarding the ROAAM methodology. He requested the peer review results to support assessment of the severe accident analysis.

We also requested an equipment survivability assessment. We requested additional information regarding the accident management program for guidance and training on the design features, and we requested a more rigorous evaluation of severe accident mitigation design alternatives. That came up a little bit yesterday with the purpose of GE doing a Level 3 PRA, and the results do feed into this analysis.

We requested GE to include the contribution from all accident classes in the containment performance. We requested additional information about the lower drywell flooding. This relates to the asbestos steam explosion probability. We requested information about the timing and when the level of water in the lower drywell -- when that would happen.

We requested additional detail on the BiMAC system. I think that is going to be a major topic in the review. Additional details were requested regarding corium splash shield and protection of the lower drywell sumps by the BiMAC.

Let's see. We requested expanded assessment of PRA uncertainty and importance analysis addressing -- This relates to key containment related features, assumptions and operator actions, and detailed information regarding containment isolation provisions related to containment failure modes.

Those were the questions that we had on Level 2. Then the additional questions are Level 1 questions. The first set were primarily for at power, and then some additional questions at the end will be regarding shutdown. That's Marie's area.

So the first question on Level 1 was a systematic assessment of the impact of thermal hydraulic uncertainty in the PRA models and results, and the main issue there is assessing the MAAP Code for use against the TRACG Code.

CHAIRMAN APOSTOLAKIS: I thought there was -- the main issue was passive systems. That's what it is.

MR. SALTOS: Nick Saltos. -- with passive systems because of the nature of the guided forces in the Maxus model compared to the plant systems, and errors and uncertainties in the thermal hydraulic parameters can be compared to the guided forces themselves.

CHAIRMAN APOSTOLAKIS: What kind of parameters do you have in mind?

MR. SALTOS: Decay heat --

CHAIRMAN APOSTOLAKIS: But if you have water flowing down, you know, from a height of several meters at least, don't you have enough force there? Do you really care about these?

MR. SALTOS: But it's not just that. It's natural circulation. It's gravity. We want a systematic approach, because everything with hydraulics depends -- with a valve here, what happened before? What succeeded? What failed?

CHAIRMAN APOSTOLAKIS: Are you focusing on the uncertainties in the various parameters or are you also raising the question of maybe some of the basic assumptions are bounding the geometry of the system, for example?

MR. SALTOS: That, too. Yes, all those can be. Geometry, numerical methods could be. Those are -- MAAP, how good MAAP is.

DR. DENNING: But you are also -- I mean, I think that this question really also addresses the question of the probability of failure of the system that is associated with phenomenological uncertainty as opposed to what's happening now for the passive systems. Their failures are all being determined by the failures of certain components.

MR. SALTOS: Yes.

DR. DENNING: I think this is really an important issue and one that I think the committee ought to have a presentation on later. I think it's a good question.

MR. SALTOS: Yes. GE is preparing a topical report on that.

MS. CUBBAGE: All right. There has been significant discussion, and we've already had one meeting just on this one RAI.

CHAIRMAN APOSTOLAKIS: I know this is an issue for core designs that are based on gas cooled. When are we going -- I mean, I would like to supplement -- get involved in this. Is October too soon? That's okay.

MR. WACHOWIAK: I'm not prepared to answer that.

CHAIRMAN APOSTOLAKIS: Okay. The real

question here, I think, is whether these uncertainties you mentioned may, in fact, change the success criteria. As you say here, the assumed success criteria will change.

MR. SALTOS; We don't know that. It may change, and the change could be important or it might not change. We don't know that.

CHAIRMAN APOSTOLAKIS: I suspected as much.

MS. CUBBAGE: Okay. We requested more documentation of the process for selecting the RTNSS systems. The initial submittal included only the fuel pool and auxiliary system connection to refill the PCC and IC pools with the firewater system, and they have also recently added the BiMAC system. So we want to look more closely at what other systems could or should be included in RTNSS control.

CHAIRMAN APOSTOLAKIS: Isn't the whole idea behind this -- how do you pronounce it, RTNSS? -- to do something -- to take some structural defense in depth measures, because the uncertainty is so much. I think that's the whole idea.

MS. CUBBAGE: That's part of it, and also from a probability standpoint you look at systems that are risk significant, non-safety systems.

MR. SALTOS: Nick Saltos again. The idea is that the non-safety systems are not regulated. They are no regulations for that, and we want them to meet the safety goals, the associated safety goals pretty much for CDF without these systems. And if they cannot meet those goals without these systems, considering even uncertainties, then they will have to take credits for those systems, and then we get regulation for those systems, some kind of regulation.

CHAIRMAN APOSTOLAKIS: Wait a minute. Wait a minute. The focus PRA without the active systems shows 10^{-5}.

MR. SALTOS: So 5 times 10^{-5} taking credit for the fire pumps which already came in as a candidate for regulation. So then there are uncertainties on top of that that we haven't considered yet, and this number could increase and go up, and some other systems might come in.

MS. CUBBAGE: And I think I really wanted to mention that the shutdown aspects here are important as well.

MS. POHIDA: I asked this RAI, because no RTNSS evaluation was done for shutdown, and the shutdown -- The focus PRA was done for two reasons. One is to look at the risk impact of only grading safety related systems. Second of all is in shutdown the decay heat removal function is provided by a non-safety related system. It is not covered in tech specs. Okay?

So if you have multiple challenges or multiple challenges to the loss of the RHR function in this plant, that is going to change the shutdown risk.

What I'm saying is the likelihood of losing the RHR function, the decay function, could be increased, but it is being provided by a non-safety related system that is not covered in tech specs.

In the AP1000 plant, because the decay heat removal function also is not provided by a safety related system, we had availability controls -- okay? -- that were done to maximize the availability of the RHR function during shutdown conditions and its support systems. That type of assessment was not done yet.

CHAIRMAN APOSTOLAKIS: But is it possible that you find yourself in a situation where you say, no, the system is too important, it should be a safety related system?

MS. POHIDA: Could be. This analysis hasn't been completed yet. The output of the RTNSS process for AP1000 was that the decay heat removal --

I mean the RHR system at shutdown and its support systems were not covered in tech specs, but they had availability controls placed on these systems.

CHAIRMAN APOSTOLAKIS: I mean, with a RTNSS system is not to declare something safety related, but do something about it. That's really what it is.

MS. POHIDA: Especially, it can influence the likelihood or increased likelihood of initiating events, which are challenges to the decay heat function.

MS. CUBBAGE: Okay. We requested a lot of additional supporting information to be submitted by GE, including cut sets and --

CHAIRMAN APOSTOLAKIS: Excuse me. Has anybody ever used the PRA in, as you say here, the RTNSS process?

MS. CUBBAGE: Yes.

MR. SALTOS: This review is for the AP600 and AP1000.

MS. CUBBAGE: The process was established during the --

CHAIRMAN APOSTOLAKIS: I know the process.

MS. CUBBAGE: And was used on the -- and it is a passive plant issue, and this is the only other passive design that we have reviewed in addition to AP600.

CHAIRMAN APOSTOLAKIS: AP600 was not as passive as this one. Right? Was it?

MS. CUBBAGE: I guess you could consider this plant to be more passive, yes.

We are waiting for GE to identify the design requirements in the DCD that came out of the PRA so that we could set ITAAC, if necessary or see all action items to verify the assumptions in the PRA.

We have requested references for component reliability data. We have requested evaluations of important human actions and associated human errors probabilities.

You heard a lot today about the fire analysis. A lot of what Rick is doing now is in response to this RAI. We asked about the fire analysis.

CHAIRMAN APOSTOLAKIS: Good.

MS. CUBBAGE: And again, fire and floods at shutdown, which was an issue that Rick covered in detail today. That came out of this RAI.

We also requested some information about the large release frequency risk during shutdown. Do you want to elaborate on that one at all, Marie?

CHAIRMAN APOSTOLAKIS: Let me understand something here. You keep referring to the goals, the subsidiary goals. The way I know them is that the CDF should be less than 10^{-4}, and the LRF for existing reactors should be less than 10^{-5}.

Now you guys sometimes say LRF should be less than 10^{-6}. Is that a new thing?

MR. SALTOS: Yes. Well, this was developed in a SECY paper back then when we were developing the policy for the AP600, and it was set to six.

CHAIRMAN APOSTOLAKIS: Is that the new thing now?

MR. SALTOS: It was developed in late Eighties, early Nineties.

CHAIRMAN APOSTOLAKIS: I know t he original was 10^{-6}. Then somehow it became 10^{-5}, and now we are back to 10^{-6}.

MR. SALTOS: Yes. Well, not changed since then. That was in the early Nineties.

CHAIRMAN APOSTOLAKIS: Well, it's 10^{-5}, isn't it? It goes up and down.

MS. CUBBAGE: We will look up the SECY paper. We can provide a reference on that.

DR. KRESS: The new reactors will now be

10^{-6}.

DR. DENNING: Yes. An order of magnitude on both CDF and LRF.

CHAIRMAN APOSTOLAKIS: Yes, but these guys are -- at 10^{-4} for core damage frequency.

DR. KRESS: Yes, that ought to be 10^{-5}.

DR. DENNING: What did you say they were doing? You mean, because they talked about when they didn't take credit for the passive safety systems they got?

CHAIRMAN APOSTOLAKIS: No, several times people have referred to the goals, and it's 10^{-4}, and 10^{-6} for LRF, and I don't understand.

DR. KRESS: I don't either.

CHAIRMAN APOSTOLAKIS: Nick said it.

MR. SALTOS: This is more conservative.

CHAIRMAN APOSTOLAKIS: Yes. The 10^{-4} is not conservative.

MR. SALTOS: 10^{-4} -- Well, this is without the defense in depth, the active systems. That was the agreement at that time to meet these goals without taking credit of the defense in depth active systems.

CHAIRMAN APOSTOLAKIS: So the goal is for evolutionary -- a 10^{-4} without the active systems, and 10^{-6}.

MR. SALTOS: Yes. Those were the criteria for bringing in for regulation non-safety active systems.

MS. CUBBAGE: You said evolutionary. That's a term that gets thrown around a lot. ABWR would be evolutionary, and these are advanced.

CHAIRMAN APOSTOLAKIS: Yes, but they are not Gen. 4. They are not the Gen. 4 stuff.

MS. CUBBAGE: Right.

CHAIRMAN APOSTOLAKIS: It's just way into the future.

MS. POHIDA: Was there anymore questions on RAI-02, the large release frequency? The reason why I asked that question was--

DR. KRESS: That's not LE RAI. That's RTL RAI. Right?

MS. CUBBAGE: Yes. The large release frequency at this plant is drawn in by events at shutdown. So that's a little bit of a different risk profile than what we've been accustomed to in a plant, and we want to understand this risk profile. So I want to understand about this containment closure, if other events could influence that frequency, and what-not. So --

DR. KRESS: But it doesn't have to be

early?

DR. DENNING: There is no such thing as early.

MS. CUBBAGE: I think GE just want it all as LRF rather than trying to differentiate the timing.

MR. WACHOWIAK: That's correct. Everything tends to be longer. We weren't trying to try to split hairs to say something is early versus late. We said, if it's a release, it's a release.

We actually didn't do much on the LARC.

MS. CUBBAGE: Just a release.

These additional issues that are listed here were identified in meetings subsequent to issuance of that RAI letter, and they have addressed those in the PRA Rev. We were asking questions about the RCS strain valve path and free seals. Again, the LRF contribution with the containment open; the impact of whether the BiMAC is available or not on the --

CHAIRMAN APOSTOLAKIS: Why would that be an issue?

MS. CUBBAGE: Which one?

CHAIRMAN APOSTOLAKIS: The BiMAC.

MR. PALLA: This is Bob Palla with staff. What we were trying to look at is the relationship between the Level 2 and the ability of this design to meet the safety goals, if one didn't credit the BiMAC system.

Now it's basically a system that at this point is conceptual. There is a lot of technical details that would still need to be worked through, and the way that GE has proposed to do this would basically transfer the responsibility for a lot of that to the COL applicant, like the testing program.

So -- and another element of this was the ROAAM process in -- The traditional reliance of that process on peer review is quite heavy. In fact, from what we can tell from what GE has submitted regarding the peer review process, it really was not very robust.

So we have called into question the degree to which we should be crediting this BiMAC system. Obviously, a number of you have expressed some reservations about a 99 percent reliability of a system that is still conceptual. So we are kind of considering how we are going to approach that in this design certification, and we are going to consider the amount -- you know, perhaps backing off, what if you only assume this thing worked 50 percent of the time. How would that impact the results?

Now the way that GE has modeled it, it is kind of a simplified approach, and I think that basically all of -- If you did that "what if" and didn't credit for BiMAC, basically those releases would go to preventive release. Now if you credited an overlying water pool as having some effectiveness, then you could slice it and dice it, and a fraction of that would still be coolable even without BiMAC. But the reason for asking this question is just to try to parse out how much of the -- how significant would the results change if you didn't credit it at all.

We are going to consider looking at some other -- What if you considered less credit for it?

CHAIRMAN APOSTOLAKIS: Well, you said, you know, what if it is 50 percent.

MR. PALLA: What if it is not there?

CHAIRMAN APOSTOLAKIS: Why don't we put just the distribution? Well, I understand that.

MR. PALLA: Well, if it's not there, it would be nothing different than ABWR was and we certified a design without the system.

CHAIRMAN APOSTOLAKIS: No, I know it is not there, but instead of being sensitivities, assuming different -- I mean, just for the distribution. But the rest of it doesn't include any uncertainty analysis. Right?

MR. PALLA: I mean, to me, you have to know a lot more to do an uncertainty analysis than you do to do a sensitivity.

CHAIRMAN APOSTOLAKIS: Yes.

MR. PALLA: I wouldn't know how to put a distribution on it. We could try, but I think a sensitivity study is easier to understand and easier for them.

CHAIRMAN APOSTOLAKIS: What I mean is --

MR. PALLA: Maybe we could have Theo put a distribution on it.

CHAIRMAN APOSTOLAKIS: No, but I think you do that, wouldn't you have to consider the uncertainties in the rest of the analysis, though? Why single out -- You would take the whole sequences where that appears.

MR. PALLA: Well, we are not looking at --

CHAIRMAN APOSTOLAKIS: I'm not criticizing.

MR. PALLA: I think a lot of the way that this has been handled in the Level 2 analysis is through more of a bounding approach. I'm not going to say that 99 percent is bounding, but --

CHAIRMAN APOSTOLAKIS: You said there was no peer review of the ROAAM process. What do you mean? The actual application of the methodology to this problem? Is that what you mean?

MR. PALLA: Yes.

CHAIRMAN APOSTOLAKIS: Because ROAAM, I believe, has been reviewed, has it not?

MR. PALLA: The ROAAM as a methodology has been reviewed.

MR. THEOFANOUS: This is Theo Theofanous.

I do want to say that the ROAAM not only has been reviewed, but it has been used very extensively in the past to resolve the issues for the CH Mark 1 liner attack, and in those reviews, as some of you may recall, they were very contested issues.

So when we finished the study, we had something like 20 people internationally to review the process, review the results, write reports, and the reports are documented in the same documents in which they had the study.

Now on this one here, as far as the stuff that was put in yesterday, it looked to us that they were so -- I don't want to use the word trivial, but it was so simple, and the treatment was so straightforward that we didn't think -- We didn't want to try to review this again, but we picked two people that are independent experts outside of GE, outside of us, and then GE, to follow their procedures they picked, I think, four people from inside GE, just to follow their own procedures.

So we had something like six reviewers, and those are documented in the back of that document that you are supposed to have gotten in December and didn't get it. But I understand it actually came to you inadvertently.

In the back there the reports and our responses are in there also, and as you will see from there, our judgment there were no contested issues was actually correct, because there is nothing that was contested by any of those reviews, not even remotely.

So maybe what he meant, I think, is that we didn't have the same extent of peer review as in the past, like getting 20 people, and that is correct. So in that respect, it is correct. However, we did have two people independent and four people inside GE, and those reviews indicate there is nothing really to fuss about.

CHAIRMAN APOSTOLAKIS: Well, anyway you guys would respond to the RAI.

MS. CUBBAGE: Okay. It looks like we only have a couple of issues left here. One would be vulnerability --

CHAIRMAN APOSTOLAKIS: Ah, wait a minute now. Modeling of the digital I&C system in the PRA. Is that a fair question, guys? I mean, let's be reasonable.

MS. CUBBAGE: Nick, you added that one.

CHAIRMAN APOSTOLAKIS: The state of the art does not allow you to do this, and you are asking an applicant to do this, and are they going to establish a research program to do it? What exactly are you asking them to do?

MR. SALTOS: Well, the modeling is in a high bounded level. We did that for -- we did that for APR Falmouth. It is modeled in the same way. The actuation failures that we were using -- they are using this passive systems using digital I&C -- are much -- is lower compared to the actuation failure -- systems. Therefore, we wanted to see why are those smaller.

So they got four trees down to the basic events to where the knowledge we have support the data, and whatever the knowledge does not support make conservative assumptions based on knowledge in modern industry that we can use to support the data, for example, on the software.

CHAIRMAN APOSTOLAKIS: Well, I mean maybe what you investigate failures of the digital I&C in the PRA.

MR. SALTOS: It was a lot of sensitivity and bounding.

CHAIRMAN APOSTOLAKIS: You probably know that lots of research is ongoing right now, one element of which is -- I mean, you guys know how to do it.

MR. SALTOS: Well, we don't do it at that point of the day. We need to certify this design, and we certified the AP600 APR a long time ago before the research program is going to be finalized. So we needed to do something about that.

CHAIRMAN APOSTOLAKIS: Yes. You are not asking them to model. You are asking them to see whether the -- what is the input.

MR. SALTOS: Exactly, and we tried to identify those high level assumptions that would become requirements.

CHAIRMAN APOSTOLAKIS: You really like that word, don't you? Every time you stand up, you use it 10 times, requirements. You are with NRR, aren't you?

MR. SALTOS: Yes.

MS. CUBBAGE: All right. Well, that is

all I had. Unless you have any other questions, we are going to turn it over to --

CHAIRMAN APOSTOLAKIS: No, there are no other questions.

MS. CUBBAGE: Okay.

CHAIRMAN APOSTOLAKIS: I'm sorry. Members? I'm sorry.

MS. CUBBAGE: Again, this is our preliminary set of questions. We will have additional questions once the staff has an opportunity to review Revision 1 in detail.

CHAIRMAN APOSTOLAKIS: I would like to also be brief on this. All these issues are very interesting. So, you know, since we decided to have 36 more meetings, we want to get to every single one of them. Okay.

MS. CUBBAGE: All right. Office of Research, and actually the contractor, ERI, will be making the next presentation.

MR. KHATIB-RAHBAR: For those of you who don't know me, my name is Mohsen Khatib-Rahbar. I'm the principal for Energy Research, which is a company. We are supporting NRC in the severe accident area for ESBWRs.

This presentation is very similar to what we gave actually a few weeks ago. So there is very little new information on it other than keeping -- Wow, look at this. Okay.

I will give you an overview of what we are doing for the NRC, specifically what is the objective of this work. Today, primarily we are focusing on the work which has been going on for the past few months in the MELCOR development activity. So we have not really started very much in the other issues of the accidents, and the current work that we will be speaking of is the MELCOR work and the confirmatory calculations to verify the applicant's calculations.

I will share with you some preliminary results and then discuss some planned analysis and the review of activities.

The objective of this work is to support the design certification, review of the severe accident risk by the NRC. We are intending to do an independent assessment of severe accident response. Because it is a new reactor, NRC is trying to learn something about the new specific features that makes it unique.

We will also intend to look at some accident source terms as a way to verify the GE based -- MAAP based analysis General Electric has proposed for the Level 2 analysis.

The resolution of severe accident issues that was presented yesterday, of course, is primarily General Electric's responsibility, and one of the things that NRC would want to do here is to try to develop the uncertainties and initial bounding conditions. From what we have learned in the past, this is the essence of really resolving the severe accident issues.

It is not so much as whether we can calculate event clearing or not. It is an important issue. What are the uncertainties in specific conditions? How big is the hole size? How much debris you get out? What is the condition in containment, etcetera, etcetera?

So the idea here is to try to resolve or try to subjectively develop the solutions and perhaps even subject it to peer review, as it was done for AP600 and AP1000. Then finally, to look at some of the severe accident issues -- as an example, steam explosions -- and to see if NRC considers that to be something significant DCH, etcetera.

Let me also give a little bit of the MELCOR activity. The MELCOR model was developed based on the information which was submitted by General

Electric back in late 2005, and the Sandia National Laboratories, which is the developer of the code, issued the latest version of MELCOR, and we got marching orders from the NRC to use that for the analysis.

So we developed the initial MELCOR deck for 1.86. This was subjected to independent peer review by Purdue and Sandia and one of their subcontractors. The review comments was provided to us. We addressed the comments. We documented how we addressed the comments, and recognizing that we have problems with MELCOR 1.86, -- these are primarily numerical problems, performance problems -- the decision was made that we will stop that and shift back to 1.85 until these problems are resolved. Then we could come back to that.

So what we will discuss today is some preliminary results based on the older version of the code, and we have just received some revisions to 1.86, and we are trying to update this input.

You may want to know what's the major difference between 1.85 and 1.86 as far as the ESBWR is concerned. One of the things they have done in 1.86 is they have developed a molten pool model for within the reactor core, and there is also molten pool model for the lower half of the reactor pressure vessel.

How significant are these in terms of overall picture for the ESBWR, I cannot tell, but those are the recent modeling issues. Otherwise, thermal hydraulics in the codes are basically the same.

Other features of this model they have developed: It has the built into containment spray system, the venting system, all the nine yards. Of course, the BiMAC system has not been explicitly modeled, because I am not so sure that it could be modeled within MELCOR, just thinking of the sensitivity.

Also in order demonstrate that we are basically taking the correct design conditions from the reactor, we have done three accident steady state calculations with the code and compared that with the DCD results.

For some reason this does not show up. The table doesn't show up. Anyway, in your handouts you have some calculation result that shows MELCOR against the DCD results. What you will see there is the biggest difference comes in from the pressure drops across the core plate, and we requested some additional information from General Electric. Hopefully, we can resolve that, but that is really not a major concern for severe accidents, because pressure drops are really not a concern, just as far as that is concerned.

The scenario that we have just picked up to analyze as a preliminary case is a dominant scenario risk contributor in ESBWR. We have zero, and in the short term -- It's a lot of feedwater. Short term and long term fuel and injection -- is not available. The ADS is activated on level. The heat removal by isolation condenser is not corrected, and the PCC and IC pool makeup is available, and is in our analysis. We assumed different makeup of these, and also GDCS deluge system is available and credited in the analysis.

We considered two cases, you know, one case where MCCI was suppressed, basically affecting, I think, a perfect BiMAC system; and the second case, which is an obvious case that MCCI is credited. This behaved very much like other small volume containments.

Again, for some reason the picture doesn't show up in here, but what does show up --

CHAIRMAN APOSTOLAKIS: It doesn't.

MR. KHATIB-RAHBAR: Maybe the font is different than the --

CHAIRMAN APOSTOLAKIS: Oh, okay.

MR. KHATIB-RAHBAR: Maybe I can go through.

CHAIRMAN APOSTOLAKIS: No, that's okay. That's all right. You can see it here now.

MR. KHATIB-RAHBAR: Can you all see this? Really, the differences in results primarily coming from some of the uncertainty in the assumptions that -- As documented in the DCD, we don't really have enough information, and modular electric and other calculations were run, and most showed actual differences in the code.

These are not really significant, but basically, the position of the team, the comparisons are remarkably good, given the fact that they were done with two different codes and so forth. For example, fission product releases -- this is intact containment -- are as close as one can expect to get. They are fairly reasonable.

DR. DENNING: Why would the deluge system be -- Why do you have the delay in the activation of the deluge system?

MR. KHATIB-RAHBAR: Yes. There are couple of other things. One is in the MAAP calculations, it had stayed intact for a long time after relocation of core debris to the lower half. We don't know the reasons for that. So that substantially changes the time of reactor pressure vessel failure.

MR. DENNING: Right.

MR. KHATIB-RAHBAR: The other thing is that the deluge system has a temperature sensor on the containment floor. When the temperature is -- specific temperature is reached, then the system is activated. That is currently modeled in the MELCOR that we have modeled here. We are not so sure whether that is included in the MAAP or not or whether that is, you know, manually injected or not.

DR. DENNING: Presumably, at the time of lower head penetration, you have molten debris. Why didn't it immediately activate when --

MR. KHATIB-RAHBAR: Because the thermocouple is supposed to be buried under the concrete. It's not on the surface of the concrete. Is that correct?

MR. YUAN: Zhe, you could perhaps comment on that. We assumed it to be the way the thermocouple location, at least you have assumed for your calculations.

DR. DENNING: Assume it's four hours.

CHAIRMAN APOSTOLAKIS: Speak to the microphone, please. Say who you are.

MR. KHATIB-RAHBAR: Why did it take so long for the temperature to be reached for the deluge to become activated?

MR. YUAN: I'm Zhe Yuan from ERI. I think we checked that results, because at the rate of mass and the time of mass to come down through the cavity is not sufficient enough to bring up the temperature of the floor.

MR. KHATIB-RAHBAR: Initially, you get a small quantity of debris coming out, but the debris has to accumulate to reach enough mass so it can affect the temperature. That is at least what the code calculates.

DR. DENNING: Thank you.

MR. KHATIB-RAHBAR: This just shows a comparison between --basically the containment pressurization between MELCOR and MAAP, and the results are generally okay.

If you were to assume that the BiMAX system is not there, this is a no-brainer. You will clear this containment in 24 hours.

What we plan to do is NRC has asked us to look at the risk --

CHAIRMAN APOSTOLAKIS: I'm sorry, Mohsen. Go back.

MR. KHATIB-RAHBAR: Which one?

CHAIRMAN APOSTOLAKIS: The next. Is that what Bob Palla wanted to see? Assuming that there is no BiMAC there, what happens? So you guys come down. I'm trying to understand what's going on, by the way.

MR. PALLA: Yes. This is Bob Palla. We've known that this would happen. I think there is a sensitivity study in the ESBWR PRA that would show us a similar result.

I was asking for the impact on the PRA results. This is just one sequence. I wanted to look at the sensitivity of the overall results.

CHAIRMAN APOSTOLAKIS: Very good. Thank you.

DR. DENNING: Mohsen, with MCCI what kind of cesium iodide release did you get in that case?

MR. KHATIB-RAHBAR: This is intact containment. This is an intact containment case. So the releases, again, are driven by the designed leakage rates. But of course, what gets released to the containment is -- you know, for BWR what controls the release is -- Since you get the dominant amount of cesium iodide coming in during the in-vessel phase, that's mostly going to the pool. So it's going to be contained by the pool. So very little amount of cesium iodide comes out. It's not any different than what you see in other plants.

In addition, you have a lot of water on top of the core debris heat on the containment floor. So the rest of it is stopped by that anyway.

MR. DENNING: Okay.

MR. KHATIB-RAHBAR: The rationale for selection of the scenarios that will be analyzed is to provide bounding conditions for the NRC's analysis -- for example, the FCI analysis; to enable limited comparisons to the MELCOR calculations; and also MAAP calculations also to assess the sensitivity design operational aspects, like sprays -- NRC is interested in this issue; and also to support any other objectives that NRC may have.

So this is like a moving thing, and we do calculations NRC asks us to do.

In terms of the rationale for selection of the scenarios, we have looked at the -- There's dominant scenarios, frequency dominant scenarios, and in some cases consequence dominant scenarios. So the idea is to cover the whole spectrum.

CHAIRMAN APOSTOLAKIS: We're getting insights, right?

MR. KHATIB-RAHBAR: The word that you hate.

The MELCOR deck has been completed. There is also -- Some typical calculations have been done, are available. We have identified the scenarios to be analyzed based on the draft Zero and, of course, they may change; and based on MELCOR calculations, for the most part, have been completed, but we are awaiting additional responses from General Electric on specific issues before these are finalized.

In terms of the ex-vessel analysis, we have just started looking at this issue. Initial conditions are aimed at confirming the GE calculations under identical conditions. In fact, we are going to be using a code which was developed many years ago.

We will formulate initial conditions for ex-vessel analysis, lower head failure location, typical things that one does in ex-vessel analysis, and we will perform an analysis on a wide range of conditions and parameters similar to those which were done for AP600 when we did the reviews for AP600.

That basically concludes my presentation. If there any questions, I will be happy to respond to them.

CHAIRMAN APOSTOLAKIS: With lightning speed, Mohsen.

MR. KHATIB-RAHBAR: Because I know you guys want to get to the airport. So I don't want to hold you here.

CHAIRMAN APOSTOLAKIS: Oh, you've been in this situation yourself. Any questions from the members? Okay. Thank you very much. Yes? Go ahead.

MR. WACHOWIAK: I have one point on that. I usually talk loud enough, but I don't have to do that.

CHAIRMAN APOSTOLAKIS: You always talk loud enough.

MR. WACHOWIAK: Okay. The one question about did that curve answer Bob Palla's question. The answer is no.

CHAIRMAN APOSTOLAKIS: Yes. He said it.

MR. WACHOWIAK: Okay. That curve and the other ones are just like what we had. It ignores that question. So I just want to be clear on that. That was not to represent what would happen. It's a sensitivity.

CHAIRMAN APOSTOLAKIS: We understand that, Rick. Thank you.

Any comments from the members? Okay. So then we will arrange, and Eric here will take care of it.

MS. CUBBAGE: He knows where to find me.

CHAIRMAN APOSTOLAKIS: We have a meeting. Usually the first week of October, we have the full Committee meeting. So it would have to be after. Yes, sir?

DR. DENNING: I did have a question, and that is: You are assuming no letter until after that next meeting?

CHAIRMAN APOSTOLAKIS: I hadn't thought about it. It's up to the committee, of course. We can write an interim letter, if we have anything important to say.

DR. DENNING: Everything I am seeing so far is quite constructive. So I'm not sure it changes the course of the direction. So I wouldn't see any reason to write it.

CHAIRMAN APOSTOLAKIS: Yes. Right now I am not inclined to write an interim letter, but if the members feel otherwise, we can always change our minds.

DR. BONACA: I wouldn't. I don't see

anything.

CHAIRMAN APOSTOLAKIS: There is nothing.

MS. CUBBAGE: Too preliminary. We were not expecting a letter at this time but, of course, if you do have any significant issues, the earlier we hear about them, the better.

CHAIRMAN APOSTOLAKIS: So we will probably write a letter after we receive the SER, as usual.

MS. CUBBAGE: Right.

CHAIRMAN APOSTOLAKIS: Typically, there is a separate letter on the PRA. As I recall, for AP600 we did write a separate letter, did we not? I'm not really sure.

So, no, it is not an issue of letter. It's really an issue of participatory peer review. Right? Educating the committee, raising concerns, getting the feedback from the applicant -- that's the normal way of doing business.

MS. CUBBAGE: Right. If we waited until the end of the process to get you involved, it's too late.

CHAIRMAN APOSTOLAKIS: The ACRS has changed its modus operandi for a long time now. This is participatory review.

Okay, there is nothing else then? I would like to thank the speakers. This was a very informative meeting, and I learned a lot. I gained a lot of insights.

Thank you very much.

(Whereupon, the foregoing matter went off the record at 11:30 a.m.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Reactor Safeguards Reliability and Risk Assessment Subcommittee

Docket Number: n/a

Location: Rockville, MD

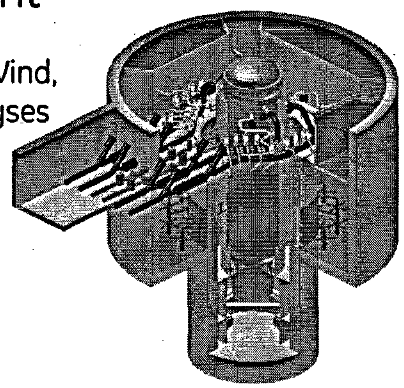
were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Eric Mollen

Eric Mollen
Official Reporter
Neal R. Gross & Co., Inc.

ESBWR External Events Risk Management

Fire, Flood, High Wind, and Seismic Analyses



Presented By:
Rick Wachowiak
General Electric
April 21, 2006

imagination at work

Probabilistic Fire Analysis

FIVE Methodology Provides the Bases for:

> Identifying fire compartments
> Defining fire ignition frequencies
> Performing quantitative screening analyses of fire risk

Risk of Core Damage due to Fire in Each of the Area Groups Should be Lower than the Risk of Core Damage due to Internal Events

Scope of Analysis

Fire scenarios in:

> Reactor Building
> Control Building
> Fuel Building
> Turbine Building
> Electrical Building
> Service Water Building

Full Power and Shutdown Modes of plant operation

Bounding Assumptions

Fires Grow Within A Building to Non-Mechanistically Affect All Equipment In A Division

> Any Fire in a Division I Room In the Reactor Building is Assumed to Damage All Division I Equipment in the Reactor Building

Fire Protection is Not Credited

Worst Case Spurious Actuation is Postulated

Fire Results

All Fire Scenarios But One Have CDF < 3×10^{-10}

Turbine Building Considered One Fire Area

Turbine Building Fire Treated as Loss of Feedwater

This Sequence Has a CDF of 1×10^{-8}

Similar to Loss Of Feedwater in Internal Events

Shutdown Fire Results

Still Under Development

Probabilistic Flooding Analysis

Initiation frequency based upon BWR experience

Flood scenarios in:

> Reactor Building
> Control Building
> Fuel Building
> Turbine Building
> Electrical Building
> Service Water Building

Full Power and Shutdown Modes of plant operation

Flooding Frequencies

At-Power Flooding Frequencies

Based on the general information contained in NUREG/CR-5750 and NUREG/CR-2300

Shutdown Flooding Frequencies

Shutdown frequencies are calculated based on the data for BWR plants for the years 1980-1996. Provided in NUREG/CR-5496.

The ESBWR flooding frequency values also accounts for a 24 month refueling outage cycle.

Reactor Building

Major water sources:

(1) Fuel Auxiliary Pool Cooling System (FAPCS)

(2) Reactor water Cleanup / Shutdown Cooling (RWCU/SDC)

(3) Reactor Component Cooling Water System: (RCCWS)

(4) Fire Protection System: (FPS)

(5) Feedwater System: FW pipe breaks are LOCA initiators. FW lines outside containment are located in the steam tunnel. A FW line break in the steam tunnel flood progression into the Turbine Building.

Control Building

Major water sources:

(1) Chilled Water System: Limited volume of water is not sufficient to cause an initiating event.

(2) Potable Water and Sanitary Waste System (PWSWS): Small water volume released.

(3) Fire Protection System (FPS): Pipes are of short length and small diameters (2-1/2 inches). The frequency and the impact of the water released is small.

Fuel Building

Potential flooding sources:

(1) Fuel and Auxiliary Pools Cooling System (FAPCS): Check valves and vacuum breaker valves eliminate potential siphon effect discharge from the fuel pool. Flooding requires a system pipe break and failure of at least one vacuum breaker valve.

(2) Reactor Component Cooling Water (RCCW):

(3) Fire Protection System (FPS): Larger FPS pipes. Water released to the FB lower floor can progress through an open doorway. Large volume of released water could cause the loss of the RWCU/SDC.

Turbine Building

Flooding sources considered are:

(1) Circulating Water System (CWS)

Flooding from a break in the circulating water system is the bounding scenario in the TB

(2) Condensate and Feedwater System (C&FS)

(3) Reactor Component Cooling Water (RCCWS)

(4) Plant Service Water System (PSWS)

(5) Fire Protection System (FPS)

Electrical Building

Flooding sources considered are:

(1) FPS system: FPS flow rate is low.

(2) RCCW: Flooding due to diesel generator cooling water system leak in a single diesel generator room is considered to be a negligible risk. Flooding in one diesel generator room would not affect the other diesel generator, and flooding in a DG room would not affect external power supplies, or cause an initiating event.

Service Water Building

The Plant Service Water System (PSWS) is the primary flood source in the Service Water Building.

The loss of service water scenario is included and analyzed in the ESBWR PRA internal events analysis by use of the Complete Loss of PSWS initiator.

The frequency of service water floods in the Service Water Building is inherently included in the Complete Loss of PSWS initiator frequency.

At Power Flooding Scenarios

AP-1: Reactor Building Outside Containment - CRDS pipe breaks outside containment.

AP-2: Reactor Building Outside Containment - FPS pipe breaks.

AP-3: Reactor Building Outside Containment - RWCU/SDCS line break outside of containment.

AP-4: Reactor Building Outside Containment - FPS line break and general transient

AP-5: Turbine Building - Complete loss of feedwater

AP-6: Turbine Building - Loss of Plant Service Water

AP-7: Electrical Building - Loss of Power Conversion System

AP-8: Diesel Generator Room – General Transient with Loss of One Diesel Generator

Shutdown Flooding Scenarios

SD-1 and SD-3: Reactor Building - CRDS pipe breaks outside containment

SD-2 and SD-4: Reactor Building Outside Containment Shutdown Flooding Scenario

SD-5 and SD-6: Reactor Coolant System Inventory Control

SD-7 an SD-8: Fuel Building Shutdown Flooding Scenarios

CDF for internal flooding

CDF for internal flooding is a not a dominant contributor to the overall plant CDF.

The contribution due to flood to the CDF is one order of magnitude less than the CDF due to internal events:

Contribution Description	CDF (per calendar year)
Internal Events	2.9E-08
Flood At-Power	3.7E-09
Flood Shutdown	1.6E-09

Key Features Important to Flood Results

- Layout and safety design features
- Safety system redundancy and physical separation provide protection from flooding by large water sources
- Alternate safe shutdown features in buildings separated from flooding of safety systems
- Watertight doors on the Control and Reactor Buildings
- Floor drains in the Reactor and Control Buildings
- Automatic CWS pump trip and valve closure on high water level in the condenser pit

High Wind Risk - Tornado

Treated as Loss of Preferred Power with No Recovery within 24 Hours

Condensate Storage Tank is Assumed Failed

Initiating Event Frequency is Much Lower than LOPP without Recovery

Risk Due to this Scenario is Very Small ~ 10^{-12}

Seismic Margins

Addresses the Capability of Safety Systems for Seismic Response

Determined Fragility for All Safety Systems

Assigned That Fragility To Each Branch of The Event Tree

> Non-Safety assigned 0.0*SSE fragility value

Fragility for the Sequence is the Maximum of Each Branch

Total Fragility is the Minimum of All the Sequences

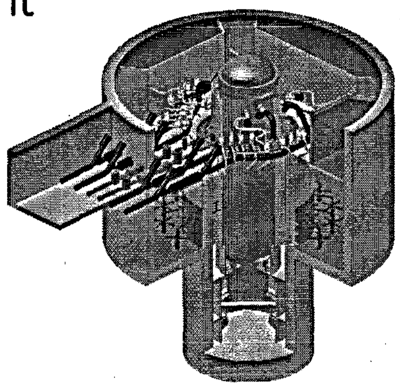
Seismic Margins Results

All Sequences Show At Least 2 * SSE Capability

Full Power and Shutdown

Unlikely the Seismic Will Be a Vulnerability

ESBWR Shutdown Risk Management



Presented By:
Rick Wachowiak
General Electric
April 21, 2006

Scope of Shutdown Analysis

- Internal Events & External Events
- Seismic Margins
- Mode 5 (Cold Shutdown)
- Mode 6 (Refuel)
- Same Level of Detail as Power Operation PRAs

Initiating Events During Shutdown

- Manual Shutdown
- LOCA – Mode 6 Only
- Loss of Power
- Loss of Shutdown Cooling
- Fires
- Floods

Not Applicable for Mode 6 With Reactor Cavity Flooded

There is More than 72 Hours to Recover DHR

Maintenance Activities During Shutdown

- Multiple Pumps / Trains of Feedwater And Condensate May be Unavailable
- Some Fire and Flood Barriers May Be Open
- ICS Out of Service in Mode 6
- 1 GDCS Pool Allowed Unavailable in Mode 6
- PCCS Unavailable in Mode 6
- SRVs and DPVs Unavailable in Mode 6

Recovery Actions During Shutdown

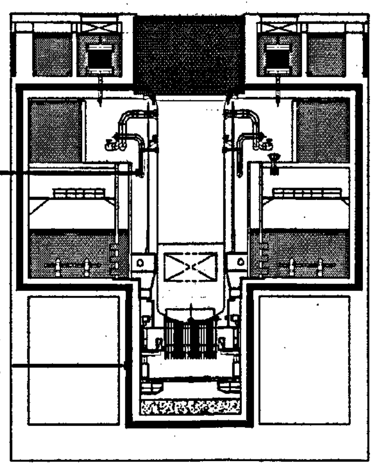
Shutdown Events Tend to Move Slower
More Time to Recover Initiating Event
Recovery Events Added to Shutdown Model
- > Recovery of Shutdown Cooling
- > Recovery of Offsite Power
- > Recovery of Service Water.

Approximately 5 Hours to Recover
Non-Recovery Value Based on Industry Events that Have Occurred During Shutdown

Shutdown CDF Results

Manual Shutdown	2×10^{-12}
Loss of DHR	$< 10^{-12}$
Loss of Service Water	3×10^{-12}
Loss of Preferred Power	4×10^{-10}
LOCA	4×10^{-9}

Containment Water Capacity During Shutdown LOCA



Shutdown PRA As A Design Tool Example

LOCA Dominated by Pipes Connected Below the Core
PRA Assumes Hatches are Open During Mode 5
PRA Assumes Containment is Open During Mode 5

GE is Considering Options to Address This Scenario

Shutdown PRA Input to Operational Programs Example

Fire Barriers Should Be Controlled During Shutdown

Remaining Intact is Best Option

Compensatory Measures (e.g. Fire Watch) are Adequate

Detailed Layout / Routing and Fire Modeling Needed to Relax This Requirement

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Final Remarks on Shutdown

Iterative Process with Design Still in Progress for Shutdown

Fire and Flood Models For Shutdown Still Under Development

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ESBWR Risk Management Insights

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ESBWR Risk Management Program

Supports Desired Goals

Scope is Appropriate

Enhanced Defense-in-Depth

PRA is a Valuable Design Tool

PRA Will Continue to Grow Through Plant Operation

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Overall Results and Observations

ESBWR Robust Design Results in Low CDF and LRF

We Are Testing The Limits of Current PRA Techniques

> Unknowns may be as important as the known

Some Screening Methods Not as Effective

> Thresholds too low to screen anything

Relative Risk Ranking Could Be A Significant Issue

> Also a threshold problem

When Compared to Other Plants, Using the Same Methods, ESBWR Provides the Best Level of Safety Available

ESBWR DESIGN CERTIFICATION PRA AND SEVERE ACCIDENTS OVERVIEW

ACRS - Reliability and Probabilistic Risk Assessment Subcommittee

April 20 & 21, 2006

PRA and Severe Accident RAIs

RAI 19.0.0-1: Requested peer review results for ROAAM methodology used to support the assessment of direct containment heating, steam explosions, and core concrete interactions for ESBWR.

RAI 19.2.3-1: Requested equipment survivability assessment.

RAI 19.2.4-1: Requested information regarding the accident management program under which guidance and training would be provided on the use of such features as containment venting, drywell sprays, and fire pumps for isolation condenser make-up.

RAI 19.4.0-1: Requested more rigorous evaluation of Severe Accident Mitigation Design Alternatives (SAMDAs).

2

PRA and Severe Accident RAIs (cont.)

RAI 19.0.0-2: GE was requested to include the contribution from all accident classes when characterizing the overall containment performance and risk for severe accidents.

RAI 19.0.0-3: Additional information was requested regarding lower drywell flooding to assess probability of containment failure due to ex-vessel steam explosion.

RAI 19.0.0-4: Additional design details were requested regarding Basemat Internal Melt Arrest and Coolability (BiMAC) system.

RAI19.0.0-5: Additional details were requested regarding the the corium splash shield and protection of the lower drywell sumps by the BiMAC cooling jacket.

3

PRA and Severe Accident RAIs (cont.)

RAI 19.0.0-6: Requested expanded assessment of PRA uncertainty and importance analysis addressing the uncertainty and sensitivity of results to key containment-related features, assumptions, and operator actions.

RAI 19.0.0-7: Requested detailed information regarding containment isolation provisions/failures related to review of containment failure modes.

RAI 19.1.0-1: Requested a systematic assessment of the impact of thermal-hydraulic uncertainty on the PRA models and results.

RAI 19.1.0-2: Requested more documentation/analyses of the process for selecting RTNSS systems (regulatory treatment of non-safety systems) including systems used during shutdown conditions.

4

PRA and Severe Accident RAIs (cont.)

RAI 19.1.0-3: Requested submittal of additional cutsets and a discussion on the use of uncertainty, sensitivity and importance analyses.

RAI 19.1.0-4: Requested that GE Identify design requirements based on PRA insights and assumptions.

RAI 19.1.0-5: Requested references for component reliability data base.

RAI 19.1.0-6: Requested detailed evaluations of important human actions and their associated human error probabilities.

RAI 19.1.0-7: Requested additional details regarding GE's fire risk analysis.

5

PRA and Severe Accident RAIs (cont.)

RAI 19.3.0-1: Requested risk assessment for fires and floods during shutdown.

RAI 19.3.0-2: Requested discussion of large release frequency (LRF) risk during shutdown.

Additional issues identified during meetings:

- Assessment of potential RCS draindown paths through the RWCU/SDC system and risk of using freeze seals
- LRF contribution from cold shutdown operations when the containment can be open
- Impact on level 2 PRA results if BiMAC is not credited
- Effect of impingement of molten core debris on the lower drywell equipment/personnel hatch
- Drywell water level at time of vessel breach
- Modeling of the digital I&C system in the PRA

6

CONFIRMATORY ANALYSIS OF SEVERE ACCIDENTS FOR ESBWR

Advisory Committee on Reactor Safeguards
U. S. Nuclear Regulatory Commission
April 21, 2006
by:

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OUTLINE

- Objectives
- MELCOR Modeling of ESBWR
- Preliminary Results
- Planned Analyses

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OBJECTIVES

- To support the design certification review of severe accident risk by NRC in
  - Independent assessment of severe accident response
  - Confirmatory assessment of representative radiological release estimates
  - Development of uncertainties in the initial and boundary conditions for analysis of selected severe accident issues
  - Confirmatory analysis of selected severe accident issues (e.g., ex-vessel steam explosion, MCCI, etc.)

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3

MELCOR Model Development

- Developed initial input decks for MELCOR 1.8.6 using GE design data
- MELCOR 1.8.6 deck subjected to an independent QA and review (Purdue & SNL/JTA)
- Review comments factored in the modification to the MELCOR 1.8.6 deck
- Due to code performance issues, the deck was finalized for MELCOR 1.8.5
- The initial baseline calculations were performed with MELCOR 1.8.5 & work is underway to finalize MELCOR 1.8.6 deck as performance issues are being resolved by SNL

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OTHER FEATURES

- Containment spray system and the venting system included
- Refill of PCC/IC pool included.
- BiMAC system not explicitly modeled
- Pre-accident steady state calculation performed prior to simulation of accidents

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MELCOR Steady-State Results vs. GE DCD Values

Parameters	Design value	Simulated value
Steam flow rate (kg/s)	2433	2436
Feedwater flow rate (kg/s)	2451	2452
Core coolant flow rate (kg/s)	9034-10584	9452
Control Rod Drive flow rate (kg/s)	5.9	5.9
Cleanup demineralizer system flow rate (kg/s)	24.3	24.3
System pressure, nominal in steam dome (kPa)	7171	7177
System pressure, nominal core design (kPa)	7240	7243
Core inlet temperature (°C)	543-545	543
Total core pressure drop (from bottom of the core support plate to top of the core) (kPa)	70.0	47.0
Core plate pressure drop (kPa)	41.3	31.5
Core maximum exit void fraction	0.916	0.90
Downcomer liquid level (m)	17.27	17.6

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6

MELCOR-Simulated Accident Scenario

- Transient event initiated by a loss of feedwater (i.e., scenario T_DP_nIN of the ESBWR PRA):
  - Short or long-term coolant injection to RPV not available (i.e., GDCS injection to RPV & wetwell injection through equalization lines not available).
  - ADS is assumed to be actuated if downcomer water level drops below 11 m.
  - Heat removal by ICs not credited.
  - PCC & PCC/IC pool makeup available (thereby allowing long-term containment heat removal).
  - GDCS deluge system is also available for injection onto the lower drywell floor.

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7

MELCOR-Simulated Accident Scenario (Cont.)

- Two cases considered:
  - ❖ Case 1: MCCI suppressed (Perfect BiMAC)
  - ❖ Case 2: MCCI allowed to occur (assuming MELCOR standard basaltic concrete composition).

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8

Comparison With MAAP Results (Case 1: Without MCCI)

Event	MAAP*	MELCOR
RPV depressurization starts (DPVs open), hour	8.6×10^{-3}	0.33
Start of core uncovery, hour	0.36	0.86
Onset of core damage (i.e., fuel temperature exceeds 2500 K), hour	0.97	1.69
RPV lower head penetration failure, hour	6.3	3.91
Deluge system actuated, hour	6.3	7.9
Containment (upper drywell) pressure at 24 hours, bar-abs	5.0	4.8
Containment (lower drywell) temperature at 24 hours, K	425	427
Containment fail/vent, hour	N/A	N/A
PCCS heat removal at 24 hours, MW	18.5	22.7
Water level in drywell at 24 hours (relative to bottom of the RPV), m	13.1	12.5
Axial concrete erosion in 24 hours, m	0.07	0.0
Mass fraction of noble gases released to environment	9.0×10^{-4}	8.7×10^{-4}
Mass fraction of CsI released to environment	7.4×10^{-5}	1.8×10^{-5}

*MAAP results taken from NEDC-33201P (Rev 0)

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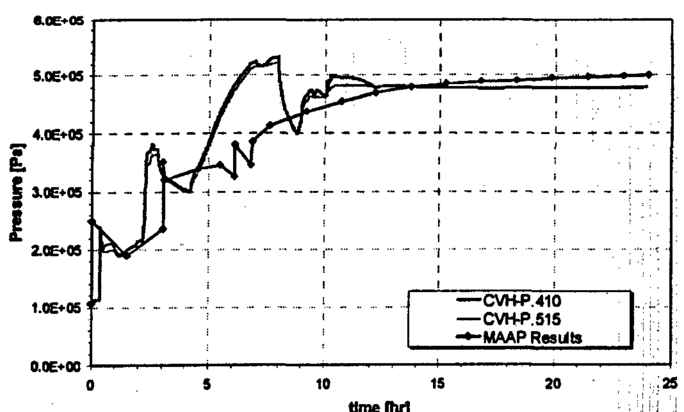
9

Upper Drywell and Wetwell Pressure

(Case 1: Without MCCI)



MAAP results taken from NEDC-33201P (Rev 0)

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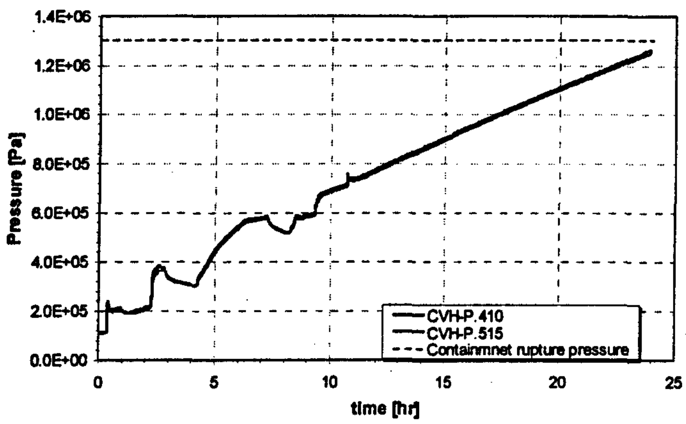
10

Upper Drywell and Wetwell Pressure (Case 2: with MCCI)



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11

Planned Calculations

- Rationale for selection of scenarios:
  - To provide initial & boundary conditions for NRC confirmatory analyses (e.g., FCI)
  - To enable limited comparison to MAAP predictions
  - To assess sensitivity to design/operational aspects (e.g., sprays)
  - To support other NRC objectives
- "Risk-dominant", "frequency-dominant", and "consequence-dominant" scenarios will be examined, together with influence of various assumptions and sensitivity cases

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12

STATUS

- MELCOR model completed and initial confirmatory calculations are underway.
  - Results of a representative accident scenario with limited comparisons to the GE submittal completed
  - Identified representative scenarios to be analyzed
  - Baseline MELCOR calculations for the most part, have been completed with the available data; however, final calculations await the receipt of requested data from GE.

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13

STATUS (Cont.)

- Ex-Vessel FCI analyses have been started:
  - Initial calculations aimed at confirming the GE calculations under identical conditions
  - Will formulate initial conditions for ex-vessel analyses:
    - Lower head failure size and location
    - Debris mass, composition and temperature
    - Etc.
  - Perform analyses to span a wide range of conditions and parameters (similar to those of AP1000)

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14