Again, Appendix I was selected as the criteria for this region, and it will be -- the frequency of events, and the events will be identified as families of events. They could exceed the Appendix I criteria if certain equipment or design features had not been put into the plant.

The consequences will be realistically analyzed for compliance with Appendix I. The second region is the design basis event region. These are events of lower frequency not expected to occur in the lifetime of a plant.

DR. POWERS: Excuse me, but I am not sure how you do the frequency analysis, and maybe you can help me a little bit. You quote .025 per plant, and that can have 10 reactors at that plant, or is it .025 per reactor?

MR. SILADY: The .025 is per plant year, and we are just making the point that for the PBMR that a plant could have up to 10 reactors, but all the assessments will be done on a per plant year basis.

DR. POWERS: Okay. So that each reactor would have a frequency of .0025?

MR. SILADY: For independent events.

DR. POWERS: And are all of the events independent?

MR. SILADY: Not necessarily in a PRA. Earthquakes.

DR. POWERS: So do you calculate the common mode --

MR. SILADY: Yes.

DR. POWERS: -- explicitly, or do you use some sort of a beta factor or something like that?

MR. SILADY: The PRA is being done now, and I think that they will use the best methods available, which generally are the beta factor approach.

DR. POWERS: What do you choose as the beta factor for a common mode between two individual reactors?

MR. SILADY: We will probably have more interactions on how we do the PRA and so on. At this point, we want to define the criteria, and we know that we have to do it per plant year, because it is kind of unique with 10 reactors.

DR. ROSEN: When you chose an example, you chose seismic as affecting more than one unit at a site, and that I think is fairly obvious to us. But are there internal events at a plant with up to 10 reactors that could affect more than one reactor?

And that comes to the question of how much isolation, how independent the individual units are intended to be, and maybe that is a design detail and I am way ahead of where you are.

MR. SILADY: Well, we would want to consider it, and we are setting it up where we can by making it per plant year.

DR. ROSEN: I am not sure you answered my question exactly.

MR. SILADY: The answer is that there are internal events. Let's say a common mode on a control room or whatever, you can think of things, and the PRA needs to do that.

DR. ROSEN: And you want a control room for all these plants as I understand in your proposed design?

MR. SILADY: Without getting into the details of the design and going into that review, the answer is yes.

DR. ROSEN: Clearly if you have one control room for 10 units, you have chances of having interactions.

DR. BONACA: I'm sorry, but I had a question on the previous page. On page 8, this is a category for anticipated operational occurrences, and then the next one you are moving to design basis. Are you planning to divide this operation on occurrences also in families of groups?

MR. BORTON: That's correct.

DR. BONACA: So you will have additional divisions inside?

MR. BORTON: That's correct, and we will plot that for you in other slides.

DR. BONACA: So it will be equivalent to the old ANSI standards with the help of a PRA?

MR. BORTON: Yes.

CHAIRMAN APOSTOLAKIS: When you say vents, you mean initiate a new vent or the whole sequence?

MR. SILADY: It is a full sequence of events.

CHAIRMAN APOSTOLAKIS: A whole sequence of events.

MR. BORTON: Yes. So for the DBE, the slide that is up there now, we looked at a lower bound frequency of 10 to the minus 4 per plant year. With events at 10 to the minus 4, you have a less than one percent chance of it occurring over the lifetime of the plant.

CHAIRMAN APOSTOLAKIS: So 10 to the minus 4 and the lifetime is 40 years?

MR. BORTON: Yes, 40 years. The criteria

was 5034 and was selected as the top level regulatory criteria for this region, and it is the family of events that could exceed that criteria if certain equipment was not afforded by the design.

There will be mean values and uncertainty ranges of consequences and are both evaluated to provide high confidence compliance with this region.

DR. ROSEN: Why do you pick 40 years? Forty years was an anachronism. Why not 12? Why not 47?

CHAIRMAN APOSTOLAKIS: Why not 60?

DR. ROSEN: Yes, why not 60?

DR. ROSEN: What is this magic 40?

CHAIRMAN APOSTOLAKIS: Sixty is good.

MR. KRICH: We agree that 60 is good, but right now the way the rules are written and the requirements of the law are, 40 years is what a license can be given for.

CHAIRMAN APOSTOLAKIS: I see. Okay.

MR. KRICH: So that was the basis for selecting 40.

DR. ROSEN: But you are going to use 50.12?

CHAIRMAN APOSTOLAKIS: They are changing so many things.

MR. KRICH: We weren't anticipating looking at that and extending the 40 years at this point in time. We were just looking at the 40 years at this point in time. But certainly if the NRC is amenable to asking for a 60 year license, then that is something that we should look at.

DR. ROSEN: I am not the NRC. I am just one member of ACRS and I don't know what 40 means. I never did.

MR. FRANTZ: This is Steve Frantz. The Atomic Energy Act also specifies a 40 year period, and that is set by law.

MR. MUNTZ: I think we are just looking to what we have been working with, and we didn't go much further than that.

DR. KRESS: You have to change so many things that you might as well not fight every fight right now. You can wait 40 years and fight that.

MR. BORTON: The last region here is the emergency planning basis event region, and these are events that are not expected to occur in the lifetime of a fleet of plants. A lower frequency was selected as 5 times 10 to the minus 7 per plant year.

That is consistent with meeting the prompt fatality safety goal, and here consequences will be realistically evaluated against the other criteria, which is protective action guides and their dose limits.

Having selected a top level regulatory criterion and defining the LBE regions, and now we could plot them, and the first thing you note about this plot is the Y access is the frequency. The event sequence mean frequency for a plant year.

The X axis is the consequences, and the solid line going through the center there, the blue, is the top level regular criteria. And below and to the left, which is the acceptable region, and above and to the right which is unacceptable --

DR. KRESS: I would like to note as an aside to the Committee that frequently stated comment that frequency consequences occurs could incorporate the whole range of regulatory requirements is now given -- this is a demonstration of that comment that I have made several times. I just wanted the committee to be aware of that.

CHAIRMAN APOSTOLAKIS: When you say on the left event sequence mean frequency, what do you mean?

MR. SILADY: It is the initiating event and any subsequent failures. It is the entire initiating event frequency and all the probabilities, the entire frequency of the end-state expressed on a mean basis.

CHAIRMAN APOSTOLAKIS: But this curve is supposed to be a complimentary cumulative curve. In other words, you shouldn't go with individual sequences here. You should go with a sum.

In other words, if I look at the curve, at the dose, and I pick 10 to the minus 1, and I go up, then all the contributions of 10 to the minus 1 or less REM should have frequencies smaller than whatever the number, 2.5 down to the minus 2.

This is an old interpretation of the Farmer curve. It was misinterpreted at the beginning that it applied to individual sequences. Now it applies to the cumulative. Otherwise -- you know the old trick. You can -- what is a sequence is not well defined.

MR. SILADY: I agree with you with regards to the comments on Farmers curve and so on, but what we were trying to do here was look at each of the top of the regulatory criteria.

Some of those are expressed in terms of an individual event, and some of them -- like the safety goal -- are cued -- and we trying to put everything on one plot very simply here, and we have had some difficulties as you can see by the footnotes as to whether it is at the EAB or EPZ, or LPZ.

And some of these are expressed in whole body, and some of them are expressed in total effective dose equivalent. We understand that when you get down close to the third region there that they have to be cued for the safety goal.

CHAIRMAN APOSTOLAKIS: The third region?

MR. SILADY: The emergency planning, and I agree with you and we will cum those. But with regards to the design basis events, the derivation of what the design basis events should be, and with regards to the derivation of what the AOO should be, we want to just look at it on a per accident family basis.

CHAIRMAN APOSTOLAKIS: You can do that separately, but this curve cannot be applied to individual sequences simply because what is a sequence is an ill-defined concept.

You can give me a sequence as you know very well, or I can give you one and you can break it up into 20 sequences, each one with 1/20th of the original frequency. Now, the staff will never accept something like that.

MR. SILADY: Right, and neither would our peer review.

CHAIRMAN APOSTOLAKIS: And I appreciate the difficulty you have, but it seems to me that this frequency -- I mean, whatever else you have to do, this curve has to be interpreted in a cumulative way.

MR. SILADY: It is cumulative for the same consequence. It is an accident family. They have to be summed for accidents, and I agree with that fully.

CHAIRMAN APOSTOLAKIS: Yes, that's what I am saying. Now, Farmer himself, when he did this in 1967, was not clear. But his argument later was that, look, whether you sum or not doesn't matter. There will be 2 or 3 of those that really dominate. And I think from that point of view that he was right.

But I think since we are starting here fresh and anew, it seems to me that it would be wise to do it correctly, and I appreciate the difficulties that you will have with other sites, but this particular curve -- and on another point, since again we are starting fresh.

There have been variations of this that some people have found convenient, and some people have not. The variation is in -- I mean, the way that you have it now, the original curve, you have an unacceptable region and an acceptable region.

One could imagine that you have a light blue curve that is below this one, and then you have three regions; the unacceptable, the acceptable, and the let's talk about it.

That gives you much more flexibility in my view when you negotiate with a regulator. And that curve I don't think you can have from the current regulations, unless you can look very carefully.

But that probably will help you. Now, on the other hand, you may not want to introduce too many new things, but that is just an idea. Now, in fairness, the Dutch did this for all their hazardous facilities, and I understand that they are not doing it anymore. So there must be a reason for that.

So I am giving you both sides of the coin, but --

MR. SILADY: It is a good suggestion, and I note that in the U.K. safety assessment that they have that.

DR. KRESS: And the Swiss have a curve similar to this which is the cumulative SC curve for the --

CHAIRMAN APOSTOLAKIS: And they agreed to that and so it has to be. This is a very good step forward. I really like this.

DR. WALLIS: I have a comment on this curve. If this were sort of risk mutual, you might like it if it was proportionally 1 over X. I mean, if we have this risk adverse approach, then the curve would dip down faster on the right-hand side.

This is actually the opposite of risk-adverse. You are allowing more, a very large risk, and the very large events. You are high. So it is not risk-adverse. It is quite the opposite. One would expect it to be more risk adverse.

MR. SILADY: Can I make a comment on this? That is a good observation, and one that we have noticed as well. But all we are doing is taking the regulations as we found them and plotting them.

CHAIRMAN APOSTOLAKIS: One other point that will come up in the future I'm sure, is that as you move to the right, the uncertainties in those frequencies of course will increase as you are very well aware.

And I wonder whether we need some guidance as to how much of that distribution, the vertical distribution and frequency, can be allowed to be above the blue curve.

And it seems to me -- well, I don't expect an answer today, but it seems to me -- unless you have it. You do have an answer?

MR. BORTON: We are going to walk through those and show some examples here.

MR. KRICH: We have established examples for ourselves that we will discuss.

CHAIRMAN APOSTOLAKIS: That's good.

MR. BORTON: I think we covered everything that was on this curve. The only thing again is that LPZ and EPZ are assumed to be at the exclusionary boundary, which gives us a little bit higher degree of margin with the top level regulatory criteria.

So once we have this, we could plot or populate the events derived from the PBMR PRA, or test some deterministically generated events against this type of plot.

CHAIRMAN APOSTOLAKIS: Now, let me understand something else and maybe that is a question for the staff. Are all the regulations embedded in this? In other words, if I do this, and I show all my sequences cumulative and so on are below the blue line, are there any other regulations that I have to meet?

MR. KING: This is Tom King from the staff. Yes, the GDCs are not embedded in this. This is a good approach to lay out the regulations that have quantitative dose criterion.

But there is a whole other set of regulations that are basically embedded in the general design criteria that have to be dealt with as part of this licensing approach. They will talk about it and we will talk about it.

MR. KRICH: 10 CFR 20 and all the other regulations, and we will talk about that later, but this is really just looking at the off-site dose affects.

MR. BORTON: But our overall approach does have to look at the whole Part 50 regulations. So as you see the fifth element and that we will go to later on, using these as a top level regulatory criteria. However, we will still have to go through each one of the regulations and address each one of them since we are not asking for --

CHAIRMAN APOSTOLAKIS: But you will declare some of them as inapplicable?

MR. BORTON: That's correct.

MR. SILADY: That's correct.

MR. BORTON: And we will tell you some of the criteria for that.

CHAIRMAN APOSTOLAKIS: Okay.

MR. BORTON: This was the PRA that we

talked about and the scoping requirements. There needs to be a comprehensive treatment of initiating events, sequences, and end states.

The PRA will include operational experience from both light water and gas reactors from here and overseas. We will address all modes of operation, including shutdown in internal and external events.

And the design characteristics that support the use of an integrated event tree structure from initiating events to end states for accident family consequences and frequencies, including their uncertainties.

CHAIRMAN APOSTOLAKIS: I don't understand this last bullet. What do you mean by support?

MR. SILADY: Well, the integrated event tree that will be developed will be like a level 1, 2, and 3 PRA integrated together. It won't be separated or split due to core damage --

CHAIRMAN APOSTOLAKIS: And this is similar to what Sandia did in 1150.

MR. SILADY: Which is classes.

DR. ROSEN: And to take advantage of the inherent features of the PBMR, I looked at some of your documentation, and you talk about doing a level three PRA and taking it all the way out.

And that raises the question of needing to have a specific site or some sort of -- or not having a site and identifying a specific site, and doing a very bounding -- or taking a very bounding approach which might penalize the design for most real sites.

MR. BORTON: That's correct. For the top level criteria that we are using here today to assess the design not against a site, but just looking at the design, we will stop at the level two PRA, and that will be the criteria which we use to assess against the top level regulatory criteria.

And the MHTGR, the 1980s and '90s afforded us some examples now to plot against this curve. As you can see there the LBEs do populate all three regions defining the events for those regions.

There are some events that do not result in off-site releases. They are on the far left. However, we can eliminate those since they are corresponding functions of the plant that prevent them from migrating or exceeding the Appendix I or 10 CFR 50.34 limits.

Again, you can see the uncertainty bands here and they plan role in the classification of the vents. DBE-6, the top arrow, and DBE-7, the mean, fall outside the DBE range. However, their uncertainty bands either fall in or are in close proximity to the DBE, and that's why they were described or classified as DBE events.

CHAIRMAN APOSTOLAKIS: Now, that is something that bothers me. Pick any one of those -- DBE 11 or somewhere in there -- so that we can all see it. The way it is presented is contrary or in conflict with the intent of the criteria, because what they are doing is they are keeping the sequence fixed, and then they are saying given these sequence of events, I am uncertain about their frequency, and I am uncertain about the consequences resulting.

The intent of the curve though, the blue curve you showed earlier, is not that. The intent is that those are independent barriers, from the end of the figure from the dose, and I go up, and all my uncertainties are on the frequency.

So you have to take this and this, and when you sum them up, then you have to do that, which is done routinely in 113 PRAs by the way, with the various contributors. Ultimately, your independent variable is the dose.

MR. SILADY: I can see that there is still a little bit of communication -- that I didn't communicate properly. I thought we had it resolved, but there is another aspect to it here.

The dose here in the DBE region, for instance, the one by DBE 11, back in the MHTGR days it was called 10 CFR 100 and now it is 10 CFR 50.34. It is 25 REM whole body it used to be, and now it is a total effective dose equivalent. It is for an event, and it is not a cum for all your design basis.

CHAIRMAN APOSTOLAKIS: The sequence is constant and then you have uncertainty regarding its frequency and its consequences. So the blue curve is different.

MR. SILADY: No, this is the blue curve. It is just the blue curve from the '80s.

DR. WALLIS: It is the same, except --

CHAIRMAN APOSTOLAKIS: You see, in the blue code, and we will go back. The way that I would read this is that I will ask myself on the horizontal access, what is the frequency of exceeding this number of RADs, right?

MR. SILADY: We are not using this as a complimentary cumulative distribution function, because 10 CFR 100, and then 50.34 weren't set up that way. It was before PRA.

So for the design basis accidents, the

traditional practice is that you take whatever the DBE is and you compare it, and you come out with hopefully a small fraction, different fractions at the construction permits stage, and then as built, of that dose.

And then you go to a different accident, another DBE, and you compare it.

CHAIRMAN APOSTOLAKIS: So what is the purpose of this curve then?

MR. SILADY: The purpose of the curve is to help us figure out with PRA insights what the corresponding DBE should be for this new kind of reactor. It is not a complimentary cumulative distribution function up there.

CHAIRMAN APOSTOLAKIS: The concept is that if you choose those correctly, and decide to withstand them for the things, and then if you did go into the cumulative complimentary distribution function, the anticipation is that you would meet that, and in my mind that proposition has never been proved.

MR. SILADY: Well, we could plot the acute and latent fatality safety goals throughout the entire region, but they aren't nearly as limiting as 10 CDR 50.35 and Appendix I are.

The point being made over here is that

because of the regulations, and not a one over X situation, or having any risk aversion in it. We are taking what the current regulations and traditional practices have been, and trying to find out if we use our PRA insights what the right DBE should be, because we have an opportunity here to set them correctly.

DR. KRESS: Essentially, this is a more definitive way to establish DBEs. I think they used judgement back in the early days to come up with the DBEs with this thinking in mind, and without ever really having to quantify.

MR. SILADY: And that's why we use that selection criteria for making it quantifiable and using the PRA quantifiable techniques, we will know.

DR. KRESS: And they may have missed some of them back then. They may have had some that were way out of bounds in terms of frequency and some of them probably should not have even been considered. But this to me is a more reasonable way of getting them on the page.

DR. KRESS: If you are going to conform to the design basis accident or concept, this is a reasonable way in my mind to choose those things, and hopefully if you choose them correctly, then you will come up with meeting this cumulative distribution curve.

CHAIRMAN APOSTOLAKIS: When you say -- and let's take an example from a light water reactor. That would be a small LOCA would it not?

MR. SILADY: Yes.

CHAIRMAN APOSTOLAKIS: And it would go to the vent for a small LOCA and through all these sequences, and add them up, right? And what I am saying is why don't you add them up also across initiating events and do it right?

MR. SILADY: Now, that is the part that I agree with you that we are going to do. Let's take a small example, like a PBMR, or a small primary coolant leak, where you have forced cooling, and you release circulating activity. You have to sum up all the ways that you can get to that consequence phenomena.

CHAIRMAN APOSTOLAKIS: Right.

MR. SILADY: And another one where you have a larger leak, and let's say a little more, plate lifted off, and then you don't have forced cooling and you have release from the core because the fuel is not perfect, and initially particles are released, and it comes out over 50 hours instead of immediately.

That is a different kind of phenomena consequence sequent. You have to sum up all the initiators for it, and it will have a different DBE number. That is what is being done here.

DR. KRESS: I think what the problem is that is having labeled those areas acceptable and unacceptable. I don't think that is the right designation for those. Those should be labeled something else.

CHAIRMAN APOSTOLAKIS: We are talking about two different curves now. I am confused on how this one will lead to the other one, because unless you do it cumulatively --

DR. KRESS: It is cumulative when you determine the overall risk status.

CHAIRMAN APOSTOLAKIS: And the acceptability is cumulative.

DR. KRESS: And that's why I say those are probably misnomers, that unacceptable and acceptable.

MR. SILADY: There are two curves, and there are acceptable and unacceptable on each curve. The first curve that we are presenting here are the regulations that are in the law, written in the law.

So, 10 CFR 50.34, we have got to meet it on a per accident basis, and later there is another acceptable and unacceptable, which is your safety goal, and you cum them with complimentary cumulative distribution function and assure that you meet that, too, in all regions.

CHAIRMAN APOSTOLAKIS: And you are not showing that today?

MR. SILADY: No, we are not showing that today. This one is to derive the licensing basis.

DR. ROSEN: Let me check my understanding here. In past licensing activities much of the discussion revolved around such topics as let me identify for you a very low probability event, and having done that the argument becomes, well, that is beyond a design basis.

To me what you have proposed here will completely finesse that discussion.

DR. KRESS: That's exactly right.

DR. ROSEN: Because no matter what a person puts on the table that is a design basis event. But it may be that your 10 to the minus 8 or 9, or 10, or 11 is below the X axis.

So you can tolerate any postulation in terms of something happening within this framework. It just ends up being of such a low probability that it doesn't have any impact on the design.

MR. SILADY: I agree, but I just want to clarify that he design basis region, what you design for, is in the middle. And that leads to these other elements that Kevin is going to get into, in terms of what is safety related, and show that only with the safety related equipment and so on.

And given that you design for that region, the design has to be able to meet the safety goals and the protective action guidelines at some distance in the region below that.

And even beyond that, ACRS or the staff may suggest other events that we both can mutually agree are below even that, and we will have to look at those, and our best estimate basis shows that the residual risk is low. So there is some finesse here, but we are still going to have a design basis region.

DR. ROSEN: Well, clearly, but my point was that for things below the 10 to the minus 4, we still have framework for discussion of them.

MR. SILADY: Exactly.

DR. ROSEN: And to come to a scrutable decision that is joint between the applicant and the staff, and the ACRS, that we have identified a sequence that is plausible, albeit very low frequency or low probability, which we know where to put on this chart. And we know how to deal with it in the regulatory aspect.

DR. BONACA: But I wanted to say that except for the user PRA, you are refining with PRA what has been done and designed in the past.

MR. SILADY: It is a hybrid, and it is using the best tools that we have and that we know today. And there are going to be uncertainties on them. This is a new reactor, but the uncertainties have to be treated as discussed.

DR. BONACA: I understand and you have a much better way to go about identifying those designs, those sequences, and having a basis for saying this should be in it and this should not be in it, and therefore defining what equipment is not going to be qualified to meet those criteria, and so on and so forth. So you have a structured approach with the benefit of a sound PRA.

MR. KRICH: Exactly. Let me stop the presentation now.

DR. BONACA: We will see, however, how later on --

DR. KRESS: But the only part is the regulations only deal with the very right-hand side of that, in terms of frequency concepts; and the other part of the blue curve as it has been defined, and I think it needs defining as part of this exercise.

CHAIRMAN APOSTOLAKIS: Is there a document that you can give us, or something that is detailed?

MR. BORTON: Details of what this approach is?

CHAIRMAN APOSTOLAKIS: Yes. Do we have that?

MR. BORTON: I have a letter that we sent to the staff on August 31st.

MR. ZEFTAWY: I have the licensing approach from Exelon, which is in the book, but it does not describe the details of the special design basis number 11, and how did he arrive at it.

MR. SILADY: You are correct that it doesn't go into this example that is shown on this chart, but it has references back to the publicly available pre-application submittals, the MHTGR PSID, that tell you what the events are and how they were assessed, and it includes the PRA. But this is just an example so that we could talk about what we intend to do.

MR. BORTON: Again, the red arrows here depict that there are required safety functions that are necessary to keep the events in the acceptable region to the right here.

And that is due to the design of the

plant. The MHTGR gives us another example here and we expect the results to be similar to those for the PBMR.

Down at the bottom here, the function of the MHTGR that are required to meet the DBE limits. So again there is radionuclide retention, control heat generation, control of heat removal, and control of chemical attack.

It is understanding these functions that become the first step in determining the third element of our approach, which is design criteria and equipment classification.

DR. WALLIS: And chemical attack includes air and water?

MR. BORTON: Yes, air and water. The third element is really in two parts here. We talk about something called regulatory design criteria, and then we are going to talk about safety classification of equipment.

And again this is how the top level regulatory criteria are met. The first part of element three is the regulatory design criteria. They are qualitative function statements, developed with risk insights, of course, because of the events which were PRA driven for each required safety function.

And now these will supplement the current light water reactor general design criteria.

DR. ROSEN: And again just to emphasize that, that is PRA supported, but expert opinion, and expert panel structured development. It is not just the PRAs.

MR. BORTON: That's correct.

DR. ROSEN: Because you don't model everything.

MR. BORTON: The PRA becomes an important step as I get into looking at the regulations for their applicability, and how they apply to the design.

And also bringing out -- this RDC though are really intended to look at things that are not currently in the regulations that are necessary, as far as design criteria.

DR. KRESS: If you intend to use importance measures for this determination of SSCs, like it has been done in some of the risk-informed applications, you will have to redefine those in terms of does or fission product releases or something?

MR. BORTON: Yes. The second part of the third element is the selection of the safety related SSCs. These are the equipment relied on to perform the required safety functions to mitigate or prevent the DBEs, design basis events.

There is two steps in this selection process, and one is real obvious, the consequence mitigation. That assures that the dose criteria are met.

The other one is for high consequence preventions, which may or may not apply with doses greater than the DBE criteria, and where we worry about the frequency of the event migrating out of the EP region into the design basis event region.

An example of how the MHTGR selected their safety related equipment, as you can see here, this is the function to remove core heat. They looked at four systems available to remove the core heat.

Some of the systems were available and some were not. However, the last two, the reactor cavity cooling system, and the reactor cavity in the surroundings -- the earth, the building -- were capable of renewing the core heat.

The RCCS, however, was selected as safety related based on the licensee's ability to demonstrate its function over the lifetime of the plant.

Now, this process was performed for all the required safety functions to mitigate design basis events, and the results are shown on the next table.

Again, this is the MHTGR example.

And this shows the relationship of the safety function with the safety related equipment.

DR. WALLIS: I'm surprised that it says radiate heat from vessel. I would think that compaction is such a big number and such a small or low temperature on this thing isn't glowing red, that radiation would be a small contribution to the heat loss.

MR. SILADY: It is primarily radiation, because the core heats up in the middle, and conducts out to the side wall.

DR. WALLIS: This is called the vessel to the outside world?

MR. SILADY: Yes.

DR. KRESS: As best as I recall, they coated the outside of the vessel with --

MR. SILADY: There were discussions on the MSTGR of increasing the humidicivity, but no decision -- and it is not likely that that will be needed for the PBMR for smaller power and power density.

DR. WALLIS: Well, humidicivity is an awkward variable. All you need is a slight change in the surface temperature and the humidicivity is probably different.

MR. SILADY: True. It is going to have an uncertainty band that you are going to have to look at a .2 to a .6, or whatever, and show that it is still acceptable.

CHAIRMAN APOSTOLAKIS: This looks like a master diagram that you can use to define initiating events, right?

MR. SILADY: It is a subset of it for that which is required for the DBEs.

MR. BORTON: So having identified these SSEs, now we can look at the special treatment to ensure their performance, which is the fourth element. The PBMR selection for the safety related equipment will follow a pretty typical practice.

Again, we are going to look at the DBE consequences and show that only using the safety related equipment could mitigate those events. We will classify the equipment during its design, fabrication, operation, and maintenance, applying special treatment to ensure its performance.

In the case of the PBMR, the special treatment requirements for classified SSEs will be developed based on the required functions for each DBE. They have a clear road map now.

In this manner a clear basis will be

established for safety related equipment, selection, and corresponding quality requirements over the life of the plant.

DR. BONACA: I guess I don't understand that very well. You are not bring PRA into this?

MR. BORTON: No, the PRA is in this. The PRA was used to look at or to define the events. The special treatment was looking at the functions. So you have very clear linkages now between the PRA, the selection of the equipment.

And now we could look at the special treatment, saying under what conditions. What is the performance parameters for those pieces of equipment now for those DPEs.

DR. ROSEN: What are the critical attributes.

CHAIRMAN APOSTOLAKIS: Well, that would depend on the redundancy.

MR. SILADY: Oh, yes.

CHAIRMAN APOSTOLAKIS: So if you go strictly by function, you may lose that benefit.

MR. SILADY: Yes.

CHAIRMAN APOSTOLAKIS: Just saying safety related equipment for SSEs are the ones that support essential safety functions is not good enough, because some of these you have only one, and some of these you have 10.

So they are not of the same value, and so I am surprised that you are not saying that there will be some sort of categorization using both safety function considerations and PRA worth of some kind.

MR. SILADY: The process uses the PRA in the front end to help fix the events, which are the events.

CHAIRMAN APOSTOLAKIS: I understand that.

MR. SILADY: Then if there is any event in that design basis region that if it were not for something in the design that it would be unacceptable, it becomes a design basis event.

And then you rerun all the design basis events with only the safety related equipment that you want to rely on, and when you do that, you find out what the temperatures, pressures, loads, are that that equipment has to be designed to.

And in that way you define the conditions that it has to operate under. And then you say what the performance requirements are, in terms of quality and so on, in order to make the assurance that it is going to be able to remove that amount of heat, and stay within that temperature and so on.

So the PRA was at the front end, but as soon as you get those events defined, it becomes more of a deterministic traditional approach.

CHAIRMAN APOSTOLAKIS: But that's what we learned from that application. You know, that a diesel generator is an important component, but it has a few thousand subcomponents.

The question is whether all of these subcomponents also safety related, regardless of what they do? The utility was complaining bitterly that they shouldn't be.

MR. SILADY: It goes function by function, and design basis by design basis event. And, for instance, the reactor vessel has three functions that it has to perform. It has to control chemical attack, and it has to maintain core geometry, and it has to radiate the heat away to remove core heat.

It is being made safety related for two of those events, for two of those functions. For example, maintain core geometry so you can get the control rods in, or to remove the core heat.

So once then you look over the spectrum of events, you get different conditions. Sometimes it is pressurized, and sometimes it is depressurized.

And sometimes the initiating event was a leak, and you go through that whole process and you find what the requirements are on the reactor vessel. And in a similar way for each of the functions you go through it.

CHAIRMAN APOSTOLAKIS: And they cannot go beyond that, because to go beyond that and do what was done for STP, you need to have the procedures in place, and you need to have operating experience, and you need to have other staff to make judgments that says that this component is not safety important as the other component.

I mean, you are missing at the design level from the mental elements for the --

DR. ROSEN: Well, clearly you are missing the operational experience, but you are not missing the ability to look at a system and say there is a lot of redundancy here from a safety function, and taking credit for that redundancy.

So there is a hint here being offered to you by ACRS.

CHAIRMAN APOSTOLAKIS: It can't be just the function.

MR. BORTON: What we meant by this third bullet is that we will have the ability to do that tracing back down to that level of detail.

CHAIRMAN APOSTOLAKIS: We will have other

--

DR. BONACA: I think that we have to argue against the design line against GDCs. That is one of the issues. What I am saying is that I think at the design stage that it is hard to do --

CHAIRMAN APOSTOLAKIS: Well, that's where people commit to things that they regret 15 years later.

MR. BORTON: And that is the point of that third bullet, is that we have the ability now to analyze to that level.

CHAIRMAN APOSTOLAKIS: When in doubt, be conservative.

DR. ROSEN: We are talking about one end of the spectrum about things that are clearly safety related and have important functions, and we are urging you to think about redundancy and taking credit for it.

On the other end of the spectrum, your process seems to be very clear, and clearly able to sort out the things that have no safety functions, and not spend a lot of money and time on those.

MR. BORTON: Things won't be unambiguous.

DR. ROSEN: Yes.

MR. BORTON: Now, we have covered the

first four --

CHAIRMAN APOSTOLAKIS: Is this clear to everyone?

DR. ROSEN: What is the question, George?

DR. BONACA: You said that the process is very clear.

CHAIRMAN APOSTOLAKIS: Well, it is not very clear. It is just clear. But I am not saying I am objecting. I just want to read more about it.

MR. BORTON: Now, having covered the first elements, and this brings us back to our model here, and just quickly going over it now. We have looked at the licensing basis criteria, and licensing basis events, and functions and equipment, and the special treatment.

The last element is to compare these risk informed design criteria and functions with the full scope of regulations in order to define the scope, which will be able to obtain a license. And again we believe that this could be done at a functional level.

And, number five, again it is elements 1 through 4, could be used to determine the applicable regulatory requirements. We will have to establish the logical rules for their selection, and Exelon provided an initial screening and results to the NRC in our letter on August 31st.

We also recognized by going through that that we are going to have to do a more detailed screening utilizing the four elements, and this is what we talked about earlier, about how that supports that in getting a more finer screen of the regulations.

We also feel that this will give us the ability to assess these regulations with consistency and repeatability, and not subject to arbitrary judgment. So what we used and essentially what this slide is trying to say is that we use this systematic logic diagram.

It's purpose was to determine what regulations apply, partially apply, or don't apply. However, it also has steps in it used to assess what regulations and guidance could be used as guidance. In other words, we didn't just throw this once we determined that it is not applicable, we don't throw it out. We look at it for guidance.

And again the first four elements of our approach help us determine what guidance is there. Certainly we also look at what guidance is necessary that is not currently in the regulations, and we have a bin for that as well.

The results of our preliminary screening is that the majority of the regulations do apply, either as required or required as guidance. And we plan to once we have some more information from the design, we will be able to do a finer screening and share that with the regulators.

DR. POWERS: I guess I am a little confused by the drawing. You look at regulation and some of them are directly applicable to PBMR, and you go down to what is to me the left side, you could use not directly applicable and you throw away. There is no route out of there.

MR. KRICH: Are you talking about partially applies?

DR. POWERS: Well, what I am saying is that I think it is this guidance business. For some reason, they applied it to the -- say a PWR.

MR. KRICH: Well, maybe by example I can maybe help answer the question. If we look at 10 CFR 50.46, which is the fuel requirements, or the performance requirements for the fuel, that regulation is written specifically for LWR fuel.

DR. POWERS: Right.

MR. KRICH: So we said, well, that clearly doesn't apply. However, we are going to need to develop the same type of performance requirements for PBMR fuel.

So we said that then needs to go -- that guidance still needs to go in there. We still need to have something that applies to PBMR fuel, along the lines of a 10 CFR 50.46.

DR. POWERS: So there is a third leg on this someplace?

MR. KRICH: No, all the legs are here. I guess I am not answering your question.

MR. BORTON: We have seven dunes, really. The ones that are shaded are the bins.

DR. SHACK: Is there a bin for -- you have guidance, but is there a bin or a new regulation is needed, and that's what I don't see.

MR. BORTON: Well, right now we are not going to ask for new rule making. It will be part of the design application.

MR. KRICH: So our intent would be that if in fact there is something that needs -- some requirement that needs to be applied to the PBMR, we would include it in our application. The NRC then would include it in their safety evaluation report back to us. So it would be imposed via that mechanism, as opposed to there is a written rule.

DR. ROSEN: You didn't talk about the deviation part of that block at all and I am surprised. When you go down to the exemption request, typically what kind of -- there are criteria in 50.12, and which of those criteria do you think will be exercised as part of this?

MR. KRICH: Well, it is hard to say. It is going to be on a case-by-case basis, but I would imagine that typically we can meet the requirement via some other mechanism. That is one of the criteria in 50.12.

MR. FRANTZ: This is Steve Frantz again. One area where we think we may need an exemption is from the requirements on operator staffing in and 50.54.

Right now those requirements are general and are not designed or specific state as applying. Only LWRs. But in fact when you go back and look at the basis for that regulation, they were developed for LWRs.

And they probably are too stringent for our pebble bed reactor or other kind of passive reactor. So we are looking at possibly getting an exemption from 50.54 requirements on operator staffing.

And you would look at the special circumstances in 50.12 and show that given a basis for that rule that it really does not apply to --

MR. KRICH: That you could meet the underlying requirement without meeting the exact requirements in paragraph M of 50.54.

DR. ROSEN: Special circumstances apply.

MR. KRICH: Exactly.

MR. BORTON: Okay. Our presentation has gone through the bulk now, and we are looking at the next two sessions to have a quick comparison with the NRC policy and practices, and specifically advanced reactor policy, and risk informed guidance.

And then finally to cover some of the objectives for our pre-application. The advanced reactor policy, we again in our August 31st letter provided to the staff a detailed comparison of the policy, and we concluded that the PBMR meets this policy.

Some of the high level things that popped out of the policy are the early interactions. Of course that is what we are doing with the staff right now in seeking their agreement on this process.

The same level of degree of protection, and we utilize the current regulations, and we develop our top level regulatory criteria from the current regulations.

The proposed specific review criteria or novel regulatory approaches. I think we meet that with our design criteria, regulatory design criteria, and with our risk-informed approach.

And finally providing enhanced margins of safety and/or utilize innovative means to accomplish their safety functions. The design of the gas reactor is noted in the policy statement as being innovative, using policy -- I'm sorry, passive systems.

And of course our discussion about meeting PAGs at site boundings will result in enhanced safety margins.

DR. ROSEN: I would point out that the safety criteria say at least the same degree of protection, and it underlined that on your chart, but you didn't say that in your words.

MR. BORTON: I'm sorry. The next slide is a comparison with the risk-informed changes and Guidance Document 1.174. The first thing to note is that it is applicable to light water reactors and license amendments.

However, the principles we felt provided useful guidance. We also sent a letter to the NRC in detail providing how we meet this Reg Guide as far as its principles. Some of the things that we highlighted was defense in depth philosophy that will be retained.

We look at providing prevention, termination of events, and mitigation of consequences, as well as providing physical multiple barriers through our design. And we do have a balance between prevention and mitigation.

Some of the other areas that we didn't touch on earlier is monitoring. We looked to monitor fuel performance with on-line refueling. The important systems like the ARCCS system, we will be looking to monitor that in its performance, and of course reactor neutronics.

CHAIRMAN APOSTOLAKIS: You said that you had a balance between prevention and mitigation. Can you elaborate on that?

MR. BORTON: Yes. I think we have another slide here. Page 56, towards the end. If you recall before, we were looking at that chart at the consequence -- what we talked about before is that we look at not only the consequences in ensuring that the safety functions could ensure that the events do not migrate to the right as you look at this plot.

We also look at the frequency as well. We talked about unique situations, and if you have a high consequence in a very low probability area, or low frequency, we still have to ensure that we can maintain that frequency through the design in order for it not to become more frequent and result in exceeding the DBE region.

MR. SILADY: Basically, when you go to look at the balance between prevention and mitigation, you have to look at each situation individually. In one case a particular SSE can serve a preventative role, and in another event, it can perform a mitigated role.

And so you really have to go in to each particular accident family and say what are the SSEs that are preventing this event from occurring, and given that it has occurred, what are the SSEs that are mitigating the consequences.

And as you go down from top to bottom in the risk chart, you will see this dual nature; that one particular SSE will be a preventive measure in one event, and be a mitigative in another.

And so it is just a question of taking a very careful look at the high risk events, and seeing which ones -- what the composite nature is over the spectrum.

MR. BORTON: The last slide that we have here is our outcomes for the pre-application activities, and working with the NRC. We were looking for agreement on the top level regulatory criteria as the limiting values.

Agreement on the risk-informed LBE selection process. Agreement on the process for equipment classification and the development of RDCs.

Comments and feedback on our approach to special treatment. Agreement on the process of determining the PBMR applicable regulations, and the reasonableness of a preliminary set of regulations.

And finally, comments and feedback that our approach is consistent with the NRC current policy and practices, and specifically in these last two areas.

Now, once this licensing approach is mutually agreed upon, it will form the basis in which we can work with the staff to resolve the other technical issues during the pre-application phase, and that concludes our presentation for this morning.

MR. KRESS: Thank you very much.

CHAIRMAN APOSTOLAKIS: When were you looking for or by when would you like these agreements?

MR. BORTON: We were looking to seek agreement from the NRC in the SECY that is coming up in November, around that time frame, so that at the end of the year we can make our decisions on whether there is a stable platform to move forward.

MR. MUNTZ: We would expect the pre-application phase to extend until next September, and we would still be expecting to have that type of interface.

DR. KRESS: I think we now turn to see what the staff's perspective on this approach is.

MR. KING: We are going to have a joint presentation from NRR research, who are working on this jointly. Eric Benner from NRR and Prasad Kadamibi from Research.

DR. KRESS: I propose in the interest of time that you skip the introductory slides that have already been covered pretty much, and then go to the slides --

MR. KING: Go right to the slides that talk about staff perspective.

DR. KRESS: Yes.

MR. KING: And what you are getting is a work in progress. You are getting a status report.

We have not finished yet.

DR. KRESS: That's understood.

CHAIRMAN APOSTOLAKIS: And are we going to have a Commission paper?

DR. KRESS: You are going to have that Commission paper in when, November?

MR. KING: The Commission paper is due at the end of November, and we would like you to look at that and give us feedback on that after your November meeting is what we would like. We are not ready to ask for it now.

MR. ZEFTAWY: You said the end of November?

MR. KING: The paper is due to the Commission at the end of November.

MR. ZEFTAWY: And we will get it the last week in October?

MR. KING: We will get it to you as soon as we can. It is written, but it is being edited and comments incorporated, and so forth. So we have a package prepared. We will get it to you as soon as we can.

But in general this whole PBMR, we have many more interactions that we need to have with you, and this is not going to be the only topic that we are going to talk about.

CHAIRMAN APOSTOLAKIS: Do you have supporting documents that explain this approach?

MR. KING: We have received from Exelon on August 31st a fairly thick package that explains this approach. You should have it. I gave copies to Medhat.

CHAIRMAN APOSTOLAKIS: Do you have it?

MR. ZEFTAWY: No. Are you talking about the one for next week maybe?

MR. KING: That is the same one. That is the same document.

MR. ZEFTAWY: Okay. That is the one in the book.

CHAIRMAN APOSTOLAKIS: Okay.

MR. KADAMIBI: Basically, you have heard that we are talking of course on treads on the ground that have already been used in the past. There was extensive work done on the MHGTR, and the staff put out a lot review documentation, and we are treating this as a run of the mill application of the regulations basically.

CHAIRMAN APOSTOLAKIS: Go to the one that says, "Staff Perspectives, General. Appears to be a reasonable and structured method for screening regulations."

MR. KADAMIBI: Yes, okay. That is number seven. Well, at the level that we are talking about, I guess what we are trying to point out over here is that the four boxes that are covered by the possibilities in the screening process seem to cover it all.

That its regulations apply, and that they are partially applicable, don't apply, or they may be PBMR specific requirements which we might include in the license condition, or tech specs, or things like that.

But in terms of -- you know, what the method does not offer, and what we find is that it doesn't really offer a way to bring to the surface safety issues that may not have been dealt with in LWR space, which is when all the regulations were done.

But there isn't an automatic process to bring up potentially significant issues, but that is the sort of thing that we will have to cover as part of or as we apply the top level regulatory criteria, and go through the licensing basis events.

We would need assurance that in fact that is a sufficiently comprehensive and complete set to support the regulatory decisions. But the other point that we wanted to make over here is that there isn't right now on the table anything that is a substitute for cool damage frequency and/or any kind of a large release.

But one could foresee that there would be things like just a calculated peak temperature within a few -- a pebble bed. You know, that would serve as a surrogate in the same way that CDF has served.

CHAIRMAN APOSTOLAKIS: Why? Why would you need that?

MR. KADAMIBI: Well, the actual core damage that I guess is in a light water reactor does not apply in a pebble bed.

CHAIRMAN APOSTOLAKIS: I understand that, but why are you looking for something to replace it with?

MR. KING: It gets back to your question, George, of the balance between prevention and mitigation.

CHAIRMAN APOSTOLAKIS: Okay. That's what I wanted to hear.

MR. KING: And what we saw on the curve, the blue curve, was -- well, after you go through the accident, here is what you get off-site basically.

CHAIRMAN APOSTOLAKIS: That's right.

MR. KING: It was nothing that dealt with the prevention piece, and so that is the issue.

MR. KING: If the Chairman of the Subcommittee agrees, can you tell us where you disagree with what we heard, because a lot of this stuff -- well, of course you have to be perceived as being independent, but are there any points where you disagree with what Exelon presented, or you don't really disagree, but you really want to think about it?

MR. KADAMIBI: I guess the level of agreement at the high level, in terms of where the four boxes in fact cover the range of eventuality, we agree there. But actually when you come down to what regulations apply or don't apply, I think we may have significant disagreements.

CHAIRMAN APOSTOLAKIS: Sure.

MR. KADAMIBI: And we haven't really gone through that. We haven't really gone through on our own either that or a similar process.

CHAIRMAN APOSTOLAKIS: That's fair enough.

MR. BRENNER: I think what we see is that the licensing approach provides a very good construct by which the applicant and the staff are going to be able to bring safety issues to the table, and discuss those issues.

While not detailed in the licensing approach, we have had a number of meetings with Exelon, and we have pointed out to them that one of the things that the staff is going to need to do is be able to bring new tables, events, and put them on the table to see where they fall given the events they have selected.

And they fully agree, and they say that is an inherent part of the licensing approach.

CHAIRMAN APOSTOLAKIS: And you are comfortable with the blue curve?

MR. KADAMIBI: Yes, as a starting point for the discussion.

CHAIRMAN APOSTOLAKIS: Oh, that is such an answer. Oh, you have been here before. Very good.

DR. WALLIS: What he said before I thought was significant. I mean, what we seem to be going through here is Exelon tells you how you should license their reactor, and I think you ought to be telling them.

And you were saying that you have not yet gone through a process like theirs to decide how you would license the reactor.

MR. KADAMIBI: That's right.

DR. WALLIS: And doesn't that have to be done rather than just accepting what they asked for?

MR. KADAMIBI: Well, the stage at which we are does not really reflect an acceptance of everything. It is really an acceptance of the validity of the approach, where you go through a screening of the regulations, and you develop some kind of an objective basis for judging acceptability and unacceptability, and trying to deal with those issues that are going to be very difficult.

And there is a proposal on the table, and we have got to begin somewhere, and we are going through it. We only got their application -- I mean, their submittal -- on August 31st, and so we haven't really had much time to --

CHAIRMAN APOSTOLAKIS: I don't know how much the fact that you have to write something by November and when you received it at the end of August, continues to the continued assurance of regulatory independence.

I mean, I agree with Professor Wallis that the approach may be technically sound, but boy, this really doesn't look very good. They are telling us how to license their reactor.

MR. KADAMIBI: Well, we are very sensitive to that perception, and at the same time the Commission has asked us to engage in early interaction.

CHAIRMAN APOSTOLAKIS: And that's very good.

MR. KADAMIBI: And so we are engaging in early interaction, and we will maintain independence and bring up the kinds of questions that -- well, I think the basis for our regulatory review will to some extent naturally bring up -- such as Reg Guide 1.174.

If we look at really how it applies in terms of defense in depth, Reg Guide 1.174 lays out seven attributes that we would look at, and we could use those as guidelines.

One of the things that we noticed is that they only used six of those seven. Now, because this is an ongoing interaction, we don't necessarily know why only 6 of the 7 were chosen.

But probably there is no reason to exclude any of those seven.

DR. BONACA: Another thing is that I don't think that they are proposing regulation. I think they are proposing a way in which they can license this plant under existing regulations it seems to me.

DR. KRESS: That's my opinion, and I don't think you should let the concept of lack of independence color your view too much. I mean, if you agree with the proposed approach as having a lot of merit, I would urge you not to let the concept of a perceived lack of independence color that.

MR. KADAMIBI: Well, we have to assure ourselves that we have a sound basis for that.

DR. KRESS: I think you are going to have to look at it and see if it is a sound basis, and is going to protect the health and safety of the public.

MR. KING: Ultimately that has to be the staff's licensing criteria.

DR. KRESS: It will be the staff's licensing criteria, no matter where it comes from.

MR. KING: Whether the bright idea comes from the staff or somebody else is secondary.

DR. KRESS: That's right. You certainly don't want to dismiss a bright idea just because it came from outside.

DR. POWERS: When you think about this licensing process, do you think about it as here is a site with a control room and a reactor, or do you think about it as a site with a control room and 10 reactors?

MR. KADAMIBI: We haven't really gotten to that point yet. I myself have not given that any thought. I don't know about Eric.

MR. BRENNER: And we early on, there was some discussion between us and the potential applicant, and the applicant stressed that they wanted to focus on the approach, versus the design.

So to that extent, we have tried to not look at particular aspects of the design, but look to make sure that the approach can handle questions like that of, well, okay, because this is different from how we have maybe licensed plants in the past, will there be a way for the staff to interject those issues as the applicant is working through the licensing approach.

And that sort of thing has been the focus of our judgment of acceptability, versus unacceptability, for the approach; as opposed to acceptability for --

DR. WALLIS: Well, you knew that you had to face this licensing of unusual reactors, and it would seem to me that the staff would know it before it saw anything from industry to look at the regulations and say how are we going to do it.

And to have some ideas generated here, and not coming all from outside, about how to license these new reactors. I have not seen any independent assessment.

All your presentation here is based on ideas that came in from outside. Weren't there some ideas here before you got ideas from outside?

MR. BRENNER: Yes, and two of the things that we have looked at already is the previous licensing of gas cooled reactors that the NRC has done, and we looked a lot at --

DR. WALLIS: So you had your own blue curves and things like that, or some sort of curve, before you saw these that came in from outside?

MR. KADAMIBI: The way that I would put it, Dr. Wallis, is that even if we used the curve as some kind of value in what we are doing, what we use it for could be quite different from what they used it for.

DR. WALLIS: Did you have any ideas before ideas came in from outside, and what did they look like?

CHAIRMAN APOSTOLAKIS: Did the Option 3 report help you at all?

MR. KADAMIBI: Yes.

CHAIRMAN APOSTOLAKIS: And would that serve a purpose of the thinking that Dr. Wallis wants?

Was there anything there that would apply to these reactors?

MR. KADAMIBI: Well, Option 3, I believe, was to support rule making.

CHAIRMAN APOSTOLAKIS: Well, 1-174 was to support the request for changes, but now it is used for other things.

MR. KADAMIBI: Well, we have gone through, I think, a relatively and systematically way to find the principles in Reg Guide 1.174, and I think we see a very clear application of some of the basic principles.

In terms of the Option 3, I think the concepts of prevention and mitigation, and how one can use quantitative analyses will be very useful. But exactly how they might be useful, I don't think we have come up with that yet.

MR. KING: The Option 3 work is very useful. Option 3 categorized events by frequency categories. That thinking applies to the thinking we heard from Exelon.

You know, the same kinds of questions that we had to wrestle with there are the same kinds of things that have to be addressed in this proposal; the balance of prevention mitigation, and that stuff applies.

CHAIRMAN APOSTOLAKIS: Yes, but there is no discussion of it here, and that is what Dr. Wallis is saying. I mean, all you are doing is you are responding to what --

DR. BONACA: Well, I want to say that for older plants that you could take right now the combination of ANSI standards, Chapter 15, and SECY goals, and draw the same curve that they have, and it would be with a band around it because they wouldn't have some foundation.

But all I am trying to say is that this is not a revolutionary approach. It is an approach that has been used before. You have not seen a blue curve, but you saw pieces of it in different portions of the regulation that you had to meet in order to license plants.

So I am saying that I don't think it was a strikingly or radically different approach.

DR. KRESS: But it puts it all together though.

DR. BONACA: It puts it all together.

DR. KRESS: And in fairness to the staff, this particular presentation was supposed to be what was their perspective and response to the Exelon proposal. We weren't asking them to say what else is out there that they might do. I am sure that they will think along those lines.

MR. KING: Or if we took a clean sheet of paper what would we come up with.

DR. ROSEN: I think that Prasad made that very clear in his remarks, that they are thinking beyond what the Exelon people put on the table.

And then the statement of what else does the staff -- what things will fall outside this protocol if that needs to be brought to the table. If you just use the protocol that they suggested and put blinders on, clearly you may miss some things. And I think that Prasad was quite clear that that is not what the staff was doing.

CHAIRMAN APOSTOLAKIS: Well, Exelon, in their last slide, stated that they wanted agreement from the staff on six processes. You know, an agreement on the process for equipment classification and the development of RDC, et cetera, and that is due up to the Commission by the end of November. That SECY will do that, will address these?

MR. KING: That SECY will go as far as we can go in November. We may have some IOUs in that SECY for follow-up activities.

CHAIRMAN APOSTOLAKIS: You guys need at least a month for reviews. So, we are talking about lightening speed here in approving all these things or agreeing.

DR. ROSEN: But where does the ACRS get involved?

CHAIRMAN APOSTOLAKIS: We don't. I guess they are going to give it to us at the last moment.

MR. KING: Well, we will get the draft SECY hopefully in a few weeks. We would like to get your views on it. As I said the SECY will go as far as it can go.

The reason that we picked November was because when we first sat down and laid out our pre-application plans and discussed it with Exelon, they were looking for feedback as soon as they could get it.

We thought that the earliest that we could get them something would be November. It may not be everything that they want, but we are trying to be reasonable, in the sense that they have decisions to make.

And they are looking for feedback, and we are trying to get them whatever we can get them by the end of the year. It gives the Commission a month to look at it.

DR. BONACA: I have a question that I would like to ask you here. Regarding the blue curve, we heard from Exelon that it is not a frequency consequence curve.

But in your presentation, you are calling it a proposed frequency consequence curve. I mean, is there confusion there on what it is and how they are using it?

MR. KADAMIBI: Our view on this is that the actual numbers on there may or may not mean a whole lot other than representing something that is of a fundamental regulatory value, which is that the higher the consequences, the less likely it should be. And this generally represents that concept. Also --

CHAIRMAN APOSTOLAKIS: There is some contributions or on individual sequences, and that is a conceptual problem that has nothing to do with the numbers.

DR. BONACA: Absolutely.

CHAIRMAN APOSTOLAKIS: The frequency consequence curve means cumulative. Now, if that is the wrong interpretation and is interpreted in a different way --

DR. WALLIS: They are not talking about

concepts. Everybody understands concepts. We are talking about hard criteria that you are going to apply to license or not license a reactor.

MR. KADAMIBI: Well, that curve I don't think will be the hard criterion.

DR. WALLIS: Well, what are they, or what ideas do you have about what they might be?

DR. KRESS: What is already in the regulations.

DR. WALLIS: What is it that you need to invent or change, or whatever?

DR. KRESS: The design or the selection of the design basis and events that will have to meet the regulations. That is what this is about.

MR. KING: They have not selected a design basis and --

DR. WALLIS: Did you know the blue curve before it was shown to you by Exelon?

MR. KADAMIBI: It was part of the MHGTR. It wasn't new and the concept has been around.

DR. WALLIS: So the idea that they are showing you something is wrong. You knew this before they showed it to you?

MR. KADAMIBI: I got it from NUREG 13-38, which is where the staff reviewed what MHGTR had proposed, and we are offered is something that the staff has spent a considerable amount of time reviewing in the past. So we want to take as much advantage of that as possible.

DR. WALLIS: Well, we knew all of this beforehand because you had been through it before, and therefore, you are in a good position to evaluate it. So, I wouldn't do away with the impression that it is something that came all from outside in some way.

MR. KING: If you were expecting we were going to come in here with a design basis, the accidents, the GDCs, and all the other criteria that we have now decided to apply, we are not ready to do that.

DR. WALLIS: No, I just wanted to get away from the impression that Exelon is telling you how to do the regulation.

DR. KRESS: Exelon is telling them what the regulations already consist of.

DR. WALLIS: Well, why do they have to tell you?

DR. KRESS: Well, they knew that. They are just putting it down on paper so that it is a point of focus.

MR. KING: What they are telling us is

that how they propose to go through the regulations and decide what applies and doesn't apply to PBMR.

DR. KRESS: Yes.

MR. KING: Their ideas as to how they would like to do it and how they would like us to agree with the way they would like to do it. Our job is to take a look at that and say does that sound reasonable or not, or do we have another way that we think it ought to be done, and that is what we are doing.

DR. ROSEN: I think that Exelon is free to propose anything that they want, but one thing that Exelon can't do is license a reactor. That can only be done by the Commission, and that is what we are doing. That is what we are looking at.

CHAIRMAN APOSTOLAKIS: I guess Graham's point is different though. He is saying that instead of starting that way, and where you have a proposal from the applicant, and you say, gee, here I agree or there is another way, he is saying why haven't you thought about other ways before you got that. I think that is the thrust of his question.

DR. KRESS: Yes, but once again, this is the way in principle that they have been licensing reactors for years, and it is just putting it down in a systematic focus and basis.

DR. POWERS: The difficulty that I am having here is that this is exactly the way they have been licensing reactors for years, and should that be the way that we do things?

I mean, shouldn't we say what is the safety that we are trying to achieve, and then define what regulations you need to achieve that? And then see which ones you have and which ones you don't have?

DR. KRESS: Yes, and to complete that picture, I would have liked to have seen the cumulative curve --

DR. POWERS: I am not wild about that, but --

DR. KRESS: But that would have defined what we were trying to achieve, and this is a way to achieve that, although there is a disconnect between them. It is not clear how this leads to achieving that other one.

But it is the same thing, and it is not clear how the design basis accident now leads to achieving the safety goals. And you can meet those rules and regulations by many different paths.

CHAIRMAN APOSTOLAKIS: I think you are going to have a hell of a problem with defensing that;

picking it out of 1.174 is --

DR. KRESS: I think the issue is going to come down to what in the heck do you mean by defense in depth.

DR. POWERS: Well, you have the challenge of with your frequency consequence curves, there are some high frequency things that you are going to allow to occur, upside events that you are going to allow to occur.

And it seems to me that I may be substantially more conservative than you and say that I don't want that kind of thing to occur, period.

And I think there is more than just defense-in-depth that is going to be a problem.

DR. ROSEN: I see another big problem, and that to me is the risk matrix. I have to define a new set of risk matrix, and --

DR. POWERS: Well, I think that CDF is shot here.

DR. ROSEN: Clearly, but I didn't hear much thinking about that from either the licensee or the staff.

DR. KRESS: Well, the matrix may be on the bottom curve there; frequency of which you exceed a certain dose there.

DR. ROSEN: But now the ACRS is defining risk as --

DR. KRESS: Well, these guys know that is --

CHAIRMAN APOSTOLAKIS: You know, I am really curious. Maybe it sounds like a crazy idea, but I would really like to understand or know how many times has industry and regulators which have been surprised by operating experience in the last 40 years, because that tells me a lot about defense-in-depth.

DR. POWERS: Can you ask the question again, George?

CHAIRMAN APOSTOLAKIS: How many times have we as a community been surprised by the operating experience.

DR. POWERS: A bunch.

CHAIRMAN APOSTOLAKIS: Well, I would like to understand that. I mean, that would be a nice little project, because that tells me how cautious I have to be for the future, which means defense-in-depth.

The words are coming are out with great difficulty, but it is the structure of the approach to defense-in-depth.

DR. POWERS: It is the correct approach.

DR. BONACA: Mr. Chairman, we are hopelessly late.

DR. KRESS: Can you guys summarize?

MR. KADAMIBI: Well, if I were to summarize, I would go to slide 12. This is really what -- this really captures many of the concerns that I have heard expressed over here and these constitute the central challenges that I think we face.

And we are cognizant of it, and the burden is heavily on the staff in order to deal with these issues. At this point, I don't think we have really seen enough about the substance of the repeat PBMR design in order to be able to say very much about any of these.

DR. WALLIS: Well, I think you have a great opportunity here to relate the top level regulatory criteria, and the real question of adequate safety and all that to the way that you apply them to this new thing.

You have a wonderful opportunity to make things more rational than they were in the past. I think just responding to someone else's idea just isn't good enough.

CHAIRMAN APOSTOLAKIS: What do you mean by enhanced level of safety margins?

MR. KADAMIBI: Well, that is an expectation I believe of the Commission, in terms of we don't require or we don't really require a higher level of safety, but through applying concepts of simplicity and passive systems, and things like that, we would expect that there would be an enhanced level of safety.

CHAIRMAN APOSTOLAKIS: Okay. Thank you, Gentlemen, and thanks to Exelon for their presentation. We will reconvene at 5 minutes past 2:00.

(Whereupon, at 1:05 p.m., a luncheon recess was taken.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

(2:05 p.m.)

DR. BONACA: All right. Our Chairman had to leave for a few minutes, and so I will be chairing this part of the meeting. Right now we are going to review the action plan to address ACRS comments and recommendations associated with the differing professional opinion of steam generator tube integrity, and I will turn to Dr. Powers, who is the Cognizant Engineer.

DR. POWERS: The Chairman of the Subcommittee will present a summary and that Chairman is Dr. Ford, formerly of General Electric.

DR. FORD: I will do exactly the same as you did. I will handle the Chairmanship.

DR. POWERS: I thought you were going to offer an opening summary.

DR. FORD: I will let you do that.

DR. POWERS: Well, being caught completely flat-footed here, that the objective is for the staff to come up and discuss a little bit on what they are doing in their steam generator action plan.

I understand that this is an action plan that has existed for some period of time, and has been augmented by the staff to address some of the comments and recommendations we made in the report that the Committee endorsed on the differing professional opinion concerning steam generator tube integrity.

I think that you will find that the staff has gone more beyond than just looking at some of our explicit recommendations, but rather has very carefully scrutinized the report, because in many places in the text we come along and say here are some thoughts and comments on this, and they have taken them to heart.

And they have come up with a plan that seems to address most of our comments. But what I don't know is who is the speaker is going to be. And let me go on and say that we did have a subcommittee meeting on this, and a substantial portion of the plan, or some portion of the plan, has been relegated to research to address.

And they have some very exciting results that are going to be presented to the Committee, and more for interest than they are for reviewing. So, with that --

MR. SULLIVAN: Well, all I am going to do is make some opening remarks. There is not too much that I have prepared on this little sheet that you didn't already go over, but since it is very short, I will just go quickly through it again.

My name is Ted Sullivan, and I am the section chief in NRR responsible for steam generators. In November of 2000, NRR prepared a steam generator action plan that addressed the activities that we were going to undertake in response to the Indian Point-2 lessons learned task group report.

And the related OIG event report on Indian Point-2, and other ongoing activities related to NEI 97-06. So that is what we did in late 2000. Then by the time of May, after we had had time to study in a fair amount of detail the recommendations in the ACRS report related to the DPO, which is NUREG 17-40, we expanded the action plan to address the activities that we were going to undertake in response to those recommendations.

The major activities as Dr. Powers indicated are being undertaken -- I think you did indicate this, but they are being undertaken by the Office of Research.

We understand that as a couple of people have said already that the purpose of this portion of the meeting is to understand how NRC is responding to the recommendations of the ACRS on the DPO.

And what we intend to do for the rest of this hour is to present a summary of the work on the near term research milestones on the actual plan, and that is what Dr. Powers was alluding to.

DR. POWERS: One thing that I would correct you about is that I don't attach anything minor -- well, the word minor does not come to mind when I think about those activities that NRR is responsible for in the action plan in responding to the recommendations.

MR. SULLIVAN: I would agree, but I think that in terms of resource expenditures --

DR. POWERS: That may be true, but the resource expenditures I agree with you, but I think the things that are going on to look for significant deviations from the expected linear response, I think that is an extraordinarily important activity, and minor is just not a word that I would attach to it.

MR. SULLIVAN: Okay. I would agree with that. I also wanted to let you know that we are not going to hit the entire steam generator action plan today or even all of the DPO issues.

But there is a description of the milestones related to all of the action plan, but in particular the DPO, on a web page that has specifically been created for the steam generator action plan.

And the staff's progress on those milestones is updated quarterly. So if you want to track that between meetings that is available. And I guess with that, I would just turn this over to Joe Muscara, who is going to lead off these presentations.

DR. POWERS: Never let it be said that a metallurgist can't handle a few engineering activities here.

MR. MUSCARA: Good afternoon. I guess by way of introduction, some of the things that I was going to say have already been said, but maybe I will just repeat them.

One of the points of interest was that when the staff reviewed the RES report, we didn't just look at the recommendations. We studied the report in detail, and when ever we found errors where there was an interest or a lack of information, we decided to address those issues also.

The report actually helped us to focus the research and to get support for it. I would also like to point out that much of the work was ongoing, and is ongoing. So they have helped us to address in the near term some of the issues that were represented in the report.

As has been mentioned, we do have an action plan, and this is updated monthly. So the current status of the work to address the DPO issues is available in the action plan.

What we were planning on doing today was to essentially address some of the recently completed research, and also to talk about some of the near term milestones.

So I will be discussing the work related to materials and inspection, and Chris Boyd will give us an overview of the thermal-hydraulics work. And he will also address some results from CFD calculations that he has completed recently.

Now, Milestone 3.1 in the action plan deals with understanding any possible crack growth during a main steam line break. The work that we are planning on doing here, we will be looking at some thermal-hydraulics evaluations to calculate the loads that are experienced by the tubes in these conditions.

This will be conducted by the staff. We will also be looking at work that has already been performed and that is available in dockets. Based on this review and in conducting thermal-hydraulics evaluations, we will come up with some upper-bound estimates of the loads.

And then with these kinds of input, we will evaluate the growth of existing range and types of cracks to see whether these cracks will propagate under the steam line break loads.

We will also be estimating the loads that are required to propagate a range of cracks, so that we can get an idea of the margin for propagating these flaws over and above the main steam line break loads.

At this point if we find that there is a great deal of margin, I think we do not need to do any further work to better define the loads, but if we do not have large margins, we will then do additional work in the thermal-hydraulics area to better define the loads.

Much of this work will be completed by the end of the next calendar year. Once the evaluations have been completed, we will also conduct some tests, including both the pressure stresses and axial and bending stresses, to essentially validate our findings from other core results.

DR. POWERS: Isn't it a case that the loading on the tubes is simple; that we have complex multi-dimensional loading that complicates these things?

What the subcommittee was thinking of were in terms of the support plates, oil canning, and even painting. And we looked upon those as very complicated loads that might be difficult to assess the magnitude of strictly by analysis.

MR. MUSCARA: Well, we will have to monitor that situation. I think the worse condition is when the tube is locked between support plates. And then we should be able to get some input from the thermal-hydraulic calculations on the kind of force that the support plates are experiencing at a particular location.

And then we will evaluate what kind of loads resulting from that, including body weight cyclic loads. And then we will evaluate the growth of cracks.

And then in the testing itself, we will try to simulate the kinds of loads that we predicted in the tubes.

DR. POWERS: I know it is probably too soon to ask the question, but I will ask anyway. You have two tube support plates, and if they go into oscillation, they don't need to be in-phase do they?

MR. MUSCARA: I suppose not.

DR. POWERS: And that would create just a horrific situation I think.

MR. MUSCARA: Well, those are the kinds of things that we have to be looking at.

DR. SHACK: And they are sort of coupled by about 5,000 tubes though.

MR. MUSCARA: Well, there are assumptions that the overload is transmitted to one tube, but many of these tubes are a lot.

DR. BONACA: So now some tubes may be a lot and some may not.

MR. MUSCARA: Right.

DR. BONACA: So you will have to look at what some range of sensitivity might be.

MR. MUSCARA: Some range, and we have to make conservative assumptions about the numbers of tubes that may be a lot.

DR. WALLIS: Has anybody got any estimates of these loads so that you know what sort of thing you are dealing with before you go on to something more complicated?

MR. MUSCARA: There have been several, and maybe a couple of submittals from the utilities, where they want to take advantage of the support plate being logged, and they are requesting the use of a higher voltage and voltage lows, and in that work they have conducted a number of analyses to try and predict those lows.

And we will be reviewing those, and in addition we will be doing our own hydraulic calculations to see how close these are.

DR. POWERS: Well, even relatively simple axial and bending loads have been done as part of setting up the alternate repair criteria.

MR. MUSCARA: I think in that case that they are assuming that the support plate was not there. So they do not have to go through that exercise.

In Milestone 3.2, we were interested in evaluating the effects of jets impinging on adjacent tubes, both under severe accident conditions, and under steam line break conditions.

Last year, we presented some results to the ACRS on work that had been conducted with respect to the erosion of tubes due to the erosion impact from severe accidents, and we had concluded at that time that the degradation was very minimal and that this was not a concern.

And the ACRS recommended that we should possibly run some longer term tests. Our original tests were 10 minute tests, and so we have since conducted some tests of a duration of 30 minutes.

And we have found that we have exactly the same data, and so even with the 30 minute testing, we still have very low rates of erosion under those conditions. And the rates range from somewhere between 2 and 5 mils per hour. So we still that is not an issue.

We conducted a number of tests to evaluate jet impingement on the steam line break conditions. Much of that work is completed, and we are doing some validation work right now on real cracks.

But I would like to show you some of the data from those tests since you have not seen it previously.

DR. WALLIS: How do you characterize the jet? It is a two-phased jet?

MR. MUSCARA: A two-phased jet. Last year, we presented work on CFD evaluations to get the properties of the jet velocities, and temperatures, and we made use of that information.

DR. WALLIS: Well, did the tests make an effort to model the upstream conditions for the jet and everything, and to get the jet velocities and quality, and everything right?

MR. MUSCARA: In the severe accident work, we used the rig at the University of Cincinnati, where we were essentially using a burner. We injected particles into this burner, and we worked on a range of velocity conditions; from very little, and up to about a thousand feet per second or meters per second.

We also found in that work, and based on the CFD conditions, that when the jet impinges on the tube, the velocity is down pretty much to nil. In our evaluations, we assumed the velocity of 200 meters per second. So we were conservative in that respect.

DR. WALLIS: Isn't that jet a steam water jet?

MR. MUSCARA: No, under severe reactor conditions it would be an aerosol, and materials evaporate from the core.

DR. WALLIS: Okay. So you have to model that somehow.

MR. MUSCARA: Right. In a steam line break, when we have a blow down facility, we reproduce the conditions inside the tubing and outside of the tubing.

Of course, on a steam line break, there is no atmosphere on the outside. So we have conducted those tests under 2400 psi pressure, at a range of temperatures.

And we find that the amount of erosion is dependent on the temperature, and it is dependent on the amount of sub-cooling. The greatest amount of erosion occurs about 280 degrees centigrade, which is about the cold wet temperature.

We would not expect to see -- well, cracks are less likely in the cold leg, and around 300 degrees C where we have the hot leg temperatures, the erosion rates are quite diminished.

DR. WALLIS: Do you understand the reason for this dramatic bump in the curve; the mountain of erosion that occurs over a narrow range of temperature?

MR. MUSCARA: Again, we need to look that this is a two hour test, and at 2400 psi, and the peak is about 27 or 28 percent.

DR. WALLIS: But why does it suddenly change under a certain temperature?

MR. MUSCARA: Well, as the temperature goes up, we are starting to get some flashing, and so the jet dissipates.

DR. WALLIS: So that is the place where it changes its two-faced conditions or something like that?

MR. MUSCARA: We think so, because based on evaluating the condition of the surface, we would see a larger area that is being affected. Also, as we penetrate into the tubing, then there is water present at the bottom and that acts as a cushion.

So the tests that we conducted for longer times would not get any greater penetration than --

DR. WALLIS: Is this a condition where the jet forms bubbles, which then collapse by cavitation on the target?

MR. MUSCARA: No, we don't believe that is the case under these test conditions.

DR. SHACK: Well, I have a conflict of interest here, but at the 300 and 320, the jet will flash obviously given enough time under all these conditions, because it is under pressure and temperature.

But since it is a transient thing, we can sort of see from the impact area that it hasn't flashed at 280 or lower temperatures. There is no flashing that goes on. The diameter of the impact area is the same as the diameter of the exit hole.

And at 300 to 320, it is flashy. You know, the impact area is spread out.

DR. WALLIS: And so that is more benign?

DR. SHACK: That is more benign. You know, we are getting small droplet impacts. The guess is that we are getting a short of bundle cavitation damage there at the peak, and when it drops off again, we are not getting the cavitation damage.

But it is very difficult to really know anything except that the peak goes up and the peak goes down.

DR. WALLIS: But there is a small window there where you will form bubbles in the jet and it can collapse on the target. You have to have just the velocities and temperatures just right for that to happen.

DR. SHACK: And it seems to be that degree of sub-cooling that you just happen to get in the cold leg?

MR. MUSCARA: We are currently conducting additional tests at different pressures, and so we are trying to understand this better.

DR. WALLIS: Is there literature on this bubble formation cavitation in a jet which is close to flashing? Is there literature on that?

DR. SHACK: We can't find any.

DR. WALLIS: I remember that I thought about it in various circumstances, and I don't know of any literature either.

DR. WALLIS: There is lots of literature

ont the droplet impact, but --

DR. WALLIS: No, that is not it. It is the bubbles that have to form, and then they have to collapse.

DR. SHACK: And it clearly is a lot more dangerous.

MR. MUSCARA: We are planning on providing some topical reports by the end of the calendar year to describe the work on the jet impingement under severe accident conditions, and also on main steam line break conditions.

So there should be a lot more detail available at the end of this calendar year. Milestone 3.6 of the action plan addresses the issue of the POD. And the ACRS made some comments as to the possible better use of other parameters rather than a constant POD.

Fortunately, we have been doing work in this area for a number of years, and we were trying to quantify the ability of flood detection using current techniques and commercial teams for realistic kinds of flaws.

We had completed work in the past, but we recently completed some of the analyses of this work, and I thought it might be useful to show you some of those results.

The POD that we are using now is a constant number of .6 POD for any size or any voltage flaw. Without going through a great deal of detail, what I wanted to show you is that we now have data on the POD as a functional flaw depth, and as a functional voltage; and four different kinds of flaws in different locations; ID and OD SCC at the support plate, and at the tube sheet, and the free span.

And besides depth, flaw depth and boltage, we were also evaluating the data against the parameter MCP. This is a fracture mechanics parameter, and MCP describes essentially the stress consideration in the ligament at the cracked tip.

MCP is a functional of both the flaw length and depth. So it is very strongly dependent on flaw geometry, and of course this dictates the failure of pressures of these tubes.

And so we have also plotted the probability of detection for flaws against this MCP parameter, and a MCP value of about 2.3 is that location where the flaw can no longer meet 3 delta-P

So what we can see from these foils is that for MCP that around 2.3 probability detection is fairly high. So a flaw that would fail under 3 delta-

P would be quite detectable.

And just to give you a feeling for the team performance, the last view graphs are based on the results from 11 teams, and in these graphs we are showing the performance on a team by team basis.

DR. WALLIS: So the probability of detection is very dependent on the people?

MR. MUSCARA: That is what this graph shows for some conditions. You will notice --

DR. WALLIS: Especially the one on the bottom right.

MR. MUSCARA: Right. At the top, we have the cracking and tube support plate cracking, and these are fairly common cracks, and so you expect to see these quite often.

What we see at the bottom is work on POD on the free span, and of course we don't get a lot of flaws in the free span, and so sometimes these confuse the inspectors, and they are not willing to call it a flaw, and they think it is something else.

In the bottom right we are showing information on the POD for the tube support plate location from stress corrosion cracking on the inside diameter. Many of our flaws that are stress corrosion cracking on the inside diameter are also accompanied by denting.

Now, the denting produces a fairly large complex signal, which makes the detection more difficult. So there is a signal there, but the inspector is to decide if this is a flaw or not. Is it a flaw, or is it the signal from the dent.

And clearly some inspectors do quite well, but then some other inspectors don't do quite as well. So we can see the range of performance we can get from team to team, which is quite useful, for example, for Monte Carlo evaluations.

DR. WALLIS: From 10 percent to a hundred percent. In one case it is a huge variation.

MR. MUSCARA: Well, it is a large variation, but again we need to look at flaws of a depth that might be of concern. So a 40 percent flaw for early detection for the worst team is not very good, but a tube can withstand -- a tube with an 80 percent through flow and 85 percent through flow can still withstand a steam line break.

DR. WALLIS: How shall I interpret that these points are in relationship to the solid curve then?

MR. MUSCARA: I'm sorry, but the solid -- these are all different symbols for different teams.

DR. WALLIS: That's right.

MR. MUSCARA: So a curve is a particular team, and a given series of points is another team.

DR. WALLIS: For the solid curve?

MR. MUSCARA: For example, the green curve --

DR. WALLIS: Well, it misses all the points in there?

MR. MUSCARA: No, the points are just a different team.

DR. WALLIS: That's right.

MR. MUSCARA: This just fit a logistic fit, and so the points are only describing not the data points, but the team performance. So the dash curve is a particular team, and the green curve is a team, and the triangles is another team.

DR. WALLIS: The green curve is a team?

MR. MUSCARA: Yes, and that team performed quite well.

DR. SHACK: That is the POD for the best team, and the dash line is the POD for the worst team; and rather than putting 11 curves where you run out of ways to distinguish them, we use symbols for the intermediate teams. And also it confuses you, Graham.

MR. MUSCARA: One thing that is worth mentioning is that the worst team was not always the worst team. That is for different flats and different locations. There was no consistency, and the worst team is not the worst.

DR. WALLIS: You should use this method for the ACRS members on what should go on a letter.

DR. POWERS: But no member is ever wrong. So there is no flaw.

DR. WALLIS: Sometimes the teams --

DR. POWERS: Low detection rate.

DR. ROSEN: Are you claiming that one of our members is flawless?

DR. POWERS: All of our members are flawless.

MR. MUSCARA: This particular view graph is not really related to materials issues, but it is the task on the item of spiking, and I guess very briefly what I want to say is that the staff has conducted a review, and it was completed this summer.

We plan on developing a staff position on this by the end of the year, and then to provide this to the public, and to have public comment, and then finalize our position with respect to ACRS comments.

The last area that I would like to address is clearly this is not an internal milestone. Noticed that we finished up in '95 or '96, but work will be going on in this area beginning the next calendar year.

And this has to do with getting a better understanding of stress corrosion cracking phenomena. So we are interested in finding out better information on cracking initiation, and crack growth, and crack evolution.

A particular interest of ours is to really understand crack evolution, because as cracks progress from their infant stage, where we have many small cracks with ligaments in between, they eventually get to a point where the ligament is small, and it no longer provides any strength. And then the cracks will join up.

The reason that the voltage based criteria works right now is because cracks really are in a infant stage, and these cracks, although they are many cracks, have ligaments, and they exhibit very high burst pressures.

But we need to understand better when we start losing the ligaments, and when we need to use a different structural integrity criterion. So we want to understand both the initiation, the evolution as a crack changes from small cracks to larger cracks, and of course the crack growth rates.

This work is really in the planning stages, and not a lot of detail is available yet, but those are the key features if you want to study them.

DR. POWERS: Is this all focused on the 600 alloy, or is it also looking at 690?

MR. MUSCARA: Thank you for reminding me. We would like to of course look at 600 because we have a lot of field experience with this material, and so we understand its behavior somewhat in the lab, but we must also understand its behavior in the field.

Along with these tests we will be conducting 690. And the idea here is to be able to understand the behavior of 690 in the field by understanding its laboratory performance, as compared to 600.

DR. POWERS: It seems to me that we really need some technical guidance on that. There are a lot of licensees coming in with 690 steam generator tubes, and they are saying, gee, scratch our inspection intervals because this material is more immune, and has more sensitivity maybe is the right word to stress corrosion cracking.

And it seems to me that we really need a technical foundation for deciding what to do there.

MR. MUSCARA: Yes. One of the things that we will be looking at for 690 is that we clearly know that the material cracks in the laboratory. And it cracks under conditions which may not be atypical of steam generator conditions, because it cracks under fairly neutral conditions in impurity environments, such as things with copper, sulfate.

And so we know the material cracks, and we want to be able to bound the conditions under which it cracks. One area of concern for us is the inspection interval.

There are two items of concern. One is that we want to stretch -- maybe industry wants to stretch the inspection interval, and secondly, we are inspecting a small sample. There is maybe 20 percent.

If we stretch the inspection interval, and some cracking is going on, and we don't catch it on time, and if we use a small inspection sample, again we need to have a great deal of degradation in the generator before a small sample picks up the problem.

So we need to be careful about the length of the inspection interval, and the sample size that we are using. Clearly the material behaves better in the laboratory than 600. So it probably has a longer useful life.

But we don't know that we can make it through 40 years. So it may be reasonable for the first inspection cycle to have a longer length, but I am not so sure that after a certain amount of time that they should not be inspecting the same kind of frequency as the materials that we are inspecting now.

DR. FORD: Joe, before you get off that one, could you comment on the relationship between this task, 3.10, which is more of a quantitative task, with that of 3.8, which is looking to see whether there is a linear bounding relationship.

MR. MUSCARA: There is a great deal of confusion with this topic. We had a very good write-up in the ACRS report, and clearly we agree that stress corrosion cracking is not a linear phenomena. We know this.

What has turned out to be linear is the correlation between the voltage growth rate -- well, since voltage does not trap crack size, it cannot track cracking rates. So the phenomena is not changing. It is only linear. The voltage seems to be linear.

So we will try and get a better understanding but I think the answer is that the voltage is not tracking what we are looking at. It is not really tracking crack growth rate.

And since there is a lot of scatter in the voltage correlation with crack size or burst pressure, you can draw almost any correlation through that data, and right now we have a linear correlation of time with voltage growth rate.

But that does not mean that is a linear corrosion between time and crack growth rate.

DR. WALLIS: If the end result is to predict as a function of time, when you have a near tube rupture event, are you saying that any current will never meet that criteria?

MR. MUSCARA: No, what I am saying is that the voltage will not meet that criteria. But we presented also last week some work, but in more detail last year.

We have been developing some techniques in the laboratory for accurate sizing of flaws. I think the critical parameters really are the flaw geometry, the flaw length and depth.

If you can't accurate measure these by any current, then you can't accurate predict the burst or the failure pressures, or the burst pressures, of the integrated tubes.

The work that we have done so far has gone quite well in predicting the failure of tubes that we have tested in the laboratory.

By using this advanced sizing technique, and then from that data predicting the burst, and we run a test, and sure enough we are within 200 psi of the burst pressure in many cases.

So the key here is not that any current can't do this job. It can, but you have to use the right parameters. And the right parameters in my view are the flaw size, and the flaw shape, and not the voltage, which does not relate to flaw tightness, or length and depth, and so on.

DR. WALLIS: So there is not a big jump in application technology? You are not talking about changing the whole NDE industry on its head.

MR. MUSCARA: We in fact are using the same probes that industry is using, 10-K probes, and what we are doing is data analysis, which is fairly different from what the industry is using.

We are doing this right now in the laboratory, and so it is not a user friendly technique at this point. But there is a lot of interest from the industry. EPRI is interested in this technique, and we recently had an e-mail from

Westinghouse. They want to come in and look at the technique, and be able to use it.

So the technique needs to be improved from a human factors point of view to make it easier to use, and we would like to make it so that there is not too much dependence on the uprater.

Right now we have a very smart guy doing the evaluations and he uses his knowledge, along with what he has programmed to come up with the right answers.

If the industry uses it, they we have to do a bit more work in making it more user friendly. And it may take some time, but it is not a huge jump at this point in the technology.

I think at this point that I am finished with the remarks that I had planned on making, and unless you have questions, we can turn it over to Chris Boyd.

DR. POWERS: Are there any more questions on the metallurgical aspects of the problem? Seeing none, we will turn to some aspects of the thermal-hydraulics issues, and some results that I think the Committee will find interesting on some of the progress that research has been making in the area of computational fluid dynamics.

We have commented several times in our research reports that we thought that this was an area that the agency could use and would profit, and the speaker will give us some idea of the progress that they are making. Thanks, Joe.

MR. BOYD: My name is Chris Boyd and I am going to talk to you today about the Division of Systems Analysis and Regulatory Effectiveness Programs in this area. And I am going to give just a quick overview of the entire division activities, and then focus in on some of the CFD work that has been done.

This overview was given in more detail last week. So based on recommendations from the ACRS subcommittee, looking at the DPO, there were two areas that our division is focusing on, and these are in the action plan, Items 3.4 and 3.1.

Item 3.4 has to do with just developing a better understanding of the behavior of the tubes during these severe accident conditions. I am going to go into a little bit of that.

And then Item 3.1 is evaluating the potential for damage due to rapid depressurization, such as a main steam line break. So in Item 3.4, looking at the tubes in the severe accident conditions, the major components of this research in our division are system level code analysis. It is the SCDAP/RELAP work.

And that is under way now, and there is a report that is just finishing up that is covering a lot of sensitivity studies and plant design differences, and things along those lines, using the workhorse code for the thermal-hydraulics.

And then we are looking with computational fluid dynamics at the inlet plenum mixing in particular, and trying to enhance what we understand of that mixing, looking or starting from the test data that we have, and then trying to enhance that, and that is what I am going to talk about today.

And then there is some additional assessment of the 1/7th scaled data, and we are looking at new experimental data, and possibilities for that. As far as the rapid depressurization goes, and its impact on the tubes, this work is scheduled for completion at the end of the next calendar year.

They are looking at the pressure loads on support plates and tubes and flow induced vibrations. This work is just now in the early formulation stages, and it was presented last week. But again this was just some preliminary thoughts.

Now I am going to focus in on some of the work. This is one of the task items, which was the --

DR. POWERS: Chris, going back to the 3.1 task, I understand that it is just in the formulation, and right now that formulation is focusing on analysis.

The complaint or the issue that comes up in this is that it is a very difficult analysis to do. Most of our codes have never been designed to get these kinds of vibrations and dynamic effects.

Are we at a place now where we can start talking about what kinds of experimental data would be needed to validate these codes. I understand that it is iterative with the kinds of things that the previous speaker was discussing on what the magnitude of the loads is.

But can we talk about the types of experiments, or is that down the road a ways?

MR. BOYD: I think it is down the road a little ways. They are still evaluating what code they might use. So ar far as benchmarking the code if you don't have the code yet, and as far as early ideas of doing hand calculations --

DR. POWERS: I had a little hope for hand calculations in this field. It's just that it is a tough calculation to do without having some experimental validation to have any confidence in what you got.

MR. BOYD: I would agree. Most codes fall into that category.

DR. POWERS: Except for chemical codes, and that goes without saying that they are all correct or all wrong.

MR. BOYD: Well, I will give you a quick overview, and I will cover this with the slides. But what we are trying to do is enhance our understanding of the inlet plenum mixing. I am showing here that thermal hydraulics reacted to this particular severe accident scenario.

This is where the core is uncovered, and where it is single-face steam, and the loop seal is plugged. So flow through the hot leg goes through part of the tubes and into the outlet plenum, and it comes back through the remaining tubes, and mixing in the inner-plenum, and this counter-current flow sets up in the hot leg.

This is modeled with SCDAP/RELAP, a lump parameter code. One of my slides has a noting diagram for that. This areas of interest that I show in the SCDAP/RELAP code is essentially three nodes, and they nodes have fixed mixing parameters that are set based on generally the 1/7th scale experiments that were done in a Westinghouse type facility.

So the idea Here is to look at those mixing parameters and look at the effect of different things on those mixing parameters. For one with CFD, we want to go full-scale, full-pressure. We want to look at the effect of a leaking tube.

We want to look at the effect of different inlet geometries, and that is what we are trying to accomplish. The first step will be to benchmark the CFD code though to see if it can pick up the right behavior, and whether it is a useful tool. And that is what we are going to talk about.

But again the background here is that the thermal-hydraulic predictions ultimately come from SCDAP/RELAP code, ad=nd that is our workhorse code.

The tube temperature predictions that come out of that are going to be influenced by these fixed mixing parameters, and these fixed mixing parameters come from a limited set of experimental data.

DR. WALLIS: You had a picture that you just showed of a steam generator with a flow going in one direction with some of the tubes, and then the other direction and the other tubes?

MR. BOYD: Right.

DR. WALLIS: This sort of situation is usually prone to historesis, but it depends on the past history which one is going where, and you can't just look at it and say 50 percent of the tubes are going one way and 50 percent of the tubes are going the other.

And maybe because of past history, you have got something of a 70-30 distribution or something. I think it is not so easy to know how to set up the program.

MR. BOYD: We are not setting it up and specifying which tubes are in an up and down flow.

DR. WALLIS: Well, then how you set it up initially, and then it evolves into something.

MR. BOYD: It evolves into something. I will say that from at least the 1/7th scale that they interrupted the entire flow pattern by opening a valve at the pressurizer line.

Their experience was that the overall flow pattern, and the number of tubes set back into its condition fairly quickly after shutting the valve again.

If you can imagine that you have got half of them going one way, and the other half going the other way, and let's say you want to go to, say, 48 percent and 51 percent.

How do those ones that were going this way, how do some of them decide then that I have got to reverse? It is not so obvious how that happens. I would assume that some are just teetering on the edge and ready to go either way.

MR. MUSCARA: Well, I would assume that some would be obviously teetering on the edge. The assumption would be nearly stagnant given that there are up flow and down flow.

DR. WALLIS: Well, in a continuum like that it may be earlier to handle.

DR. SHACK: I remember at the subcommittee meeting that you said that you diddled the conditions at the core, and you always managed to sort of set up a kind of a stable profile, and your counter-current flow.

MR. MUSCARA: That's right.

DR. SHACK: Did that affect your fractions at all? I mean, when you changed that, did you --

MR. BOYD: No, changing those conditions didn't really impact the fractions. That was a very -- it did not impact it significantly. What happened was that there were other parameters to change the impact in a much greater sense.

So I found that to be a very limited impact and that gave us confidence in setting those boundary conditions, and that was the point that I was making.

MR. BOYD: All right. I talked about the background, and the bottom line is that these SCDAP/RELAP bins are relying on mixing parameters which come from 1/7th scaled data which we are going to try and bolster the confidence in that data.

Why use computational fluids. Well, it is less expensive than experiments. We can go to full scale and full pressure. We are going to have a direct resolution of mixing. We are not setting fixed mixing parameters.

And we will then be able to extend our data within the MHTGR effects and tube leakage effects in a much wider number of variations than we could in an experiment.

DR. WALLIS: Well, let's go back to this again. The mixing is dependent upon the flow in the tubes, and presumably you have jets coming out of some tubes and so on. So the level of turbulence in the lower or left plenum is a function of how the flow is coming out of the tubes isn't it?

MR. BOYD: If I say no to mixed mixing

parameters, we are not specifying the flow in the tube. We are letting the equations --

DR. WALLIS: But the equations don't model many tubes. They just lump them together. If you limp them together, you get a very different --

MR. BOYD: Well, at 1/7th scale, we have got a tube for every tube. There are only 260 tubes here and I am modeling every one of them as an individual channel.

DR. WALLIS: And in the real generator, you can't do that.

MR. BOYD: I have my ideas on tube modeling if you want to go into that.

DR. WALLIS: Well, at least you realize that you have to do it.

MR. BOYD: Just to show a quick flow physics comparison. This is really if people understand this, but on the CF approach the hot leg, what I am showing is that we are predicting the direct counter-current flow; and in the SCDAP/RELAP calculations, you have to set up before the run, and run two pipes, and one carries one fixed temperature flow in, and the other carries a fixed one-dimensional flow back.

In the inlet plenum, in computational

fluids, we are modeling the rising buoyant plume, and letting the turbulent mixing happen, and the lump parameter code, we have got these three volumes, with fixed flow co-efficients to set up the mixing as you see on the three blocks on the right.

And then as far as the tubes go, we have got the advantage where we are going to directly predict the number of tubes in up flow where in the SCDAP/RELAP runs that is a fixed parameter again, and we had basically one set of tubes all the same temperature going up, and one set of tubes, all the same temperature, coming back.

So we will also be able to get the temperature variation, tube to tube variations, which could give us some insights.

DR. WALLIS: Again, in CFT, usually you have this K esplon model or something for turbulence, which was not developed for these conditions, and density stratification we know dampens out turbulence.

MR. BOYD: Right.

DR. WALLIS: So you need a different model if you are going to do it right.

MR. BOYD: What I did was that I looked at several turbulence models. I used K-Esplom because it is fast for a while, but I didn't want to present that here, just because I knew that you guys would pick on me if I produced K-Esplon results.

But I looked at a few other turbulence models, and they didn't make as big an effect as I thought.

DR. WALLIS: Did they take account of the Richardson number type thing, the buoyancy and killing the turbulence?

MR. BOYD: Yes, there are options for that. The one that I ended up with was a Reynolds Stress Model, and so a second order model, modeling each of the components.

DR. WALLIS: Was buoyancy in it or it doesn't does it?

MR. BOYD: Well, that is implicitly. Buoyancy is implicitly in every one, because I have got variable properties and gravities, and all the bells and whistles were on.

But I was surprised in that it did not make as big of a difference as I might have suspected. It did actually look better in some areas, the second order of turbulence though.

DR. WALLIS: It certainly looks far better than lumped parameters.

MR. BOYD: A little better than lumped

parameters. So CFD is going to provide an improved understanding at 1/7th scale, and when I say improved understanding, we have got data, but we have got limited data.

There is just a handful of thermal-couples no velocity measurements, and mass flows are inferred from external energy balances. So with CFD, you can fill in some of the gaps, and you can take a look at the errors that you might or the uncertainty that you might get by just measuring with four thermal-couples.

And assuming that you have measured enough in the hot leg to understand the full profile, and things along those lines.

DR. WALLIS: It is not a predictive tool then, and you just use it to understand data?

MR. BOYD: Well, in this case, I am saying one of our action items was to assess the 1/7th scaled data. So this is a tool that helps us assess that.

At this point though we are not really interested in this 1/7th scaled data so much as we are the full scale data. And at this point, I am showing results against 1/7th. This was our first step.

DR. WALLIS: And you eventually want to predict full scale?

MR. BOYD: That's right, and we are

working on that now and starting to build the models for full scale. Then extending the full scale, the first question --

DR. WALLIS: Full scale means predicting full scale without experiments?

MR. BOYD: That's right. We will be making predictions at full scale, that's right, down to the third decimal place.

Does scale affect the mixing parameters, and that is our first question. And at full scale, that is where I am going to look at the effect of tube leakage, and the effect of inlet geometry variations, as opposed to doing them at the small scale, where we are not really interested.

And then we can look at tube to tube variations. The schedule and the approach validate the technique to see if it is a valid approach, and with 1/7th scaled data we have done that.

Extend the predictions to full scale, and that is starting up now, and then complete these additional studies, and that is next July. So we will take a quick look at what we did at full scale.

We have got two measurements at full scale. This is the course mesh and the other mesh is actually still running several million cells. This is about a million cells for a hot leg and steam generator. They are about 5 centimeters a piece.

And cutting that down to a 2 centimeter cell case, which is what is running now, makes the mesh obviously a lot tighter, and a lot more cumbersome. But that gives you an idea of what the 3-D mesh of each of the tubes being modeled.

I look at the results in two ways, qualitatively and quantitatively. Qualitatively, they gave a handful of observations from the test, and things such as the flow coming in to 60 percent of the hot leg, and exiting the hot leg covering about 25 percent of the hot leg area, and sloping interface, of course.

This was picked up in the test. The plume or the rate of drop off of temperature in the plume roughly matched what was predicted. The temperature dropped through the tubes. Again, similarly matched all the counter current flows.

So on a qualitative basis, I am just saying that we picked up the global flow phenomena that was observed and could be talked about in that test series.

Quantitatively, when we go down to the parameters we are interested in to put into

SCDAP/RELAP, this is one of the tests that we ran. This is actually the worst set of results. We do have a little bit better, but these aren't that bad.

Generally, I would say they are within 10 percent on most of the parameters. We have overpredicted in this case a number of hot tubes, the number of tubes in upflow by approximately 10 percent of the tube sheet.

That is probably one of the larger errors, and that is something that I am looking at with sensitivity studies on the tube model. As far as things like mixing fraction and recirculation ratio, which are direct parameters that we care about int he SCDAP/RELAP runs, we generally are within 10 percent.

And in this particular case, there is a model in the recirculation ratios that is as high as 15 percent off. Given the data and the limited measurements that were made, I would say that we are within the uncertainty of the data on this.

So in general I am saying that the code has done a decent job. We are getting the big picture, and I think it is going to be a useful tool.

And when I told you that we were about 10 percent of the tube sheet off in the upflow, this is a direct picture of that. The outside dotted line is the fluent prediction of the boundary between up flow tubes and down flow tubes, the inner two lines are the boundary based on the data.

Now, that is a band because they didn't have every tube monitored. So somewhere within that band, is where the region of upflow and down flow shifts.

They reported the outer band, but I put in the inner band because that was just as likely in my mind.

DR. WALLIS: Westinghouse gets fewer --

MR. BOYD: That's right. So the results of the validation, generally I am saying that we are within 10 percent of the Westinghouse 1/7th scale. We have picked up the global flow parameters that we expected.

And I think given the uncertainty in the experimental data, we are doing very well here. And work on full-scale predictions is under way. And I think I am repeating myself here.

So I am saying that the CFD technique has been demonstrated to be applicable for the prediction of these mixing parameters, and for this kind of counter-current flow situation.

This work provides a level of confidence that CFD can be used to go beyond the experimental data to conditions not explicitly covered, such as a little variation in the inlet conditions or a variation in the height of the hot leg relative to be the tube sheet.

And further analysis as planned that full scale, with tube leakage, and these geometry effects, and other sensitivity studies.

DR. POWERS: It is just an exciting progress and I look forward to what comes out of it. It is a new level of understanding of what is going on in these flow calculations, and it would be delightful to have those variations that you are talking about, because that has been the subject of endless amounts of speculation and hand-waving, and it would be nice to have some reliable calculational results in that area.

DR. WALLIS: You said there was a run running now? I just wondered if it will be over before we leave on Saturday.

DR. KRESS: Actually, it won't.

DR. POWERS: That was the right answer; whether it was going to be done or not. All right. Any other questions on the thermal-hydraulic aspects of the action plan?

It is my impression that the staff has bent over backwards to respond to our recommendations, and it is my impression that we have helped the staff in acquainting the Commission with the fact that they need to fund research in these areas if they want the level of understanding that they would like to have.

And I see us producing an improvement in the state of the art in many areas, and certainly in the metallurgical areas, and then from this I see in the computational fluid dynamics areas.

So I think that truthfully this has been win-win situation in producing this review. Thank you very much. I will now turn the meeting back over to you, Mr. Chairman.

CHAIRMAN APOSTOLAKIS: With that, we will take our break, and meet again at 3:20.

(Whereupon, the meeting was recessed at 3:05 p.m., and was resumed at 3:20 p.m.)

CHAIRMAN APOSTOLAKIS: The last presentation of the day is on Proposed Resolution of Generic Safety Issue 173-A, Spent Fuel Storage Pool for Operating Facilities, and Dr. Kress, you are up again.

DR. KRESS: I was looking through David's slides, and he goes into the background pretty well, and so there is no need for me to make the background statements that I was going to make. I will just let him make them. So I will turn it over to him, and let him go ahead.

MR. DIEC: I appreciate that, Dr. Kress. Good afternoon. My name is David Diec, and with me today is Steve Jones from the Office of NRR. We also have the technical staff who are sitting in the background and who are available to answer any questions that you may have.

For today's presentation, I will be discussing the purpose of the presentation itself, and go over a little bit of background of what GSI-173A is about.

And the staff evaluation of plant specific issues. Steve Jones will then discuss with you the basis for the closure of this GSI and make a final conclusion.

The purpose of the presentation today is two-fold. We are addressing the recommendation that you made in the June 20th letter, and certainly we are seeking for your closure letter on this issue, as it has been a long time since we last talked to you.

The information that is being discussed today has been presented to you so many times in the past. We came before you to discuss about our action, task action plan earlier, as early as 1994, and to present our findings in 1996, and to as recently as last year, to discuss about our proposed resolution for a plant specific issues.

In the June 20th letter, the Committee raised a concern whether the screening criteria that we used were appropriate for potential plant specific evaluations for spent fuel action and its risk at operating facilities.

The impetus of the concern was that the criteria in the Reg Guide was derived from prompt fatalities at facilities, and it is probably appropriate for an operating reactor source because it was driven by a steam oxidation condition.

However, for the spent fuel pool accident, and you may be looking at the source term is different and involved with a large amount of releases of Ruthenium and fuel fines.

As a result of that, the Committee made the recommendation that we defer closing out this GSI until the technical study that we conduct on decommissioning plants is complete, and consider developing appropriate screening criteria for regulatory analysis of the spent fuel pool accidents at other facilities.

In way of background, this GSI was a genesis of the report filed under Part 21 in 1992 by two contractor engineers who performed work at the Susquehanna plants.

These engineers contended that the Susquehanna spent fuel pool failed to meet regulatory requirements with respect to sustained loss of pool cooling function after the loss of off-site power or a loss of LOCA event.

And they sustained that boiling could cause failure of equipment necessary to mitigate accidents, and to safely shut down the plants. That was the genesis of that.

In 1993, we formulated a task action plan to resolve issues associated with the spent fuel pool storage, and to ensure the reliability of the decay heat removal capability, and maintenance of the inventory in the pool.

The task action plan was completed in 1996, and we briefed you of our results, and at that time after the completion of the briefing, the Committee asked us whether or not we would like anything; i.e., a response letter.

In hindsight, we should have said yes.

But it seemed unnecessary at that time, and so that leads us to today's presentation. The task action plan looked at three generic areas; coolant inventory, and the ability to provide and maintain inventory in the pool; and to detect temperature and fuel reactivity; and the ability to maintain fuel in the sub-critical and the bar flex integrity in the spent fuel racks.

Just a note on the fuel reactivity. We addressed this issue separately as part of the generic letter in the 96-04 response. So it was not considered in this broader scope.

In doing the implementation of the action plan, we visited a number of plants, and we reviewed plant specific design features that addressed these two areas, the coolant inventory and coolant temperature, and also the reactivity issue a little bit.

And we concluded that these plants conformed to the current regulations. However, we identified a number of plant specific issues that need further regulatory evaluation; and in June of last year, we came before you to discuss specifically how we would resolve those.

I am going to go over the probabilistic

assessment that we used at that time. We performed the probabilistic assessment of these issues by first conducting a screening analysis, using plant specific design and operational information.

And two endstates were chosen to test the design features under the evaluation for inventory endstate corresponding to a loss of coolant to within a one foot level above the top of the spent fuel pool rack was used.

For issues involving boiling, an endstate corresponding to a sustained boiling in a pool for greater than 8 hours was used. The endstates represent conservative points in the sequence, where public health and safety was assured.

DR. BONACA: If I could ask a question and if you could go back a moment to that, and you are talking about consistent with regulatory guidelines, and it seems as if there is one set of requirements to which all these power plants are adhering to.

And in the license renewal, we have seen a lot of different requirements, especially for older plants, that seem to have more or less regulatory requirements imposed on the equipment.

So the question that I am asking here is this implied that it is just one set of requirements and applying to all pools, such that you can perform a generic PRA screening analysis?

MR. DIEC: We look at the number of plants and we choose a specific group of plants that represent specific plant issues, using this criteria. So I am not sure it is a blanket approach in this case.

DR. BONACA: Well, let me give you an example. We have some plants where we were told that probably none of the cooling equipment in the spent fuel pool is in their design basis.

Therefore, they only commit to maintaining the liner of the pool and the emergency injection and both of them are self-degrade and they are in the scope of the license renewal.

And we were left with some surprises on that. We are reviewing now an application where the cooling system is in the scope of license renewal, and therefore the heat exchanger and pumps, et cetera, is in the scope.

So we have a sense that there is a very different regulatory requirements applying to different plants, and that's why I was asking these questions about this generic analysis.

MR. JONES: That in essence was the

genesis of this issue. Most of the design features that we evaluated were called for in later design guidance, but we are not implemented at a lot of the earlier plants because their construction permits predated that guidance.

Things such as -- well, like safety grades, spent fuel pool cooling system, and seismic makeup lines, and things of that nature. So the purpose of the evaluation was to determine if we were justified in imposing backfill requirements to upgrade those systems.

DR. BONACA: So actually what I am raising here is it was the center of this issue, and you are going to talk about that.

MR. DIEC: After performing the analysis, we concluded that if we can see the loss of the spent fuel coolant events were less than 1E minus 6 per year, and there was no regulatory action justified for these plants, group of plants.

The frequency of suspended boiling was found between 1E minus 6 per reactor year, to 1E minus 5 per reactor year. We conducted a further evaluation of those plants and concluded that no action was justified.

The evaluation that we looked at took into consideration the licensee's voluntary actions to modify their plant piping system designs to install additional low level alarm in the pool, and a switch that will give an indication in either the control room or at the local station.

And also beefing up their operating procedures to make sure that the operator is aware of the onset of the loss of cooling events.

DR. BONACA: So the first bullet is applicable to all power plants?

MR. DIEC: All power plants that fall into the loss of cooling events.

DR. BONACA: And that includes the spent fuel pool coolant event in their licensing basis. I am trying to understand what that means.

MR. JONES: These were essentially screening analyses of certain plants that had vulnerabilities to loss of coolant events because of the way their spent fuel pools were configured or the reliability of their makeup systems.

And in the second case there were vulnerabilities with the spent fuel pool cooling system. Like it did not have an on-site source of power available to the pumps and heat exchanges.

DR. BONACA: So the conclusion for the

first question was that in no case -- I mean, the frequency of loss of spent fuel pool coolant was 1E minus 6 for all plants?

DR. KRESS: I interpreted that to mean that these individual plants would make a judgment, and if their frequency was that, then no action was required. If it wasn't, then you would have to go further with it.

DR. BONACA: So this was the conclusion. All right.

MR. JONES: We made an effort to select the most vulnerable plants and evaluate them on a plant specific basis the probability of these two events or two endstates.

And it was a bounding assessment for all the plants that had some of the design features that we were evaluating.

DR. ROSEN: And a definition of the endstate is within one foot above the top of the rack?

MR. DIEC: Correct.

DR. ROSEN: And this was based on an analysis of operational experience?

MR. DIEC: Yes.

DR. ROSEN: You are saying that the frequency has been less than 1E to the minus 6 based on operating experience?

DR. KRESS: No, it was calculated --

MR. LEE: This is Sam Lee. I was the risk analyst that worked on this, and Dr. Bonaca, you are correct. It is per plant frequency estimation, and this is all a calculated number based on operations, per se.

DR. BONACA: Thank you.

MR. LEE: Well, it is based on operations as is, but it is all based on risk analysis, or what I would call a probablistic analysis, because the endstate that we had used was one foot above the stored fuel.

DR. WALLIS: You have to have millions of years of experience, and it has got to be calculated.

MR. HUBBARD: This is George Hubbard with the plant systems branch, and I just wanted to clarify one thing. This was the risk analysis that was done by the staff and by the contractor through site visits.

They went out and they looked at the issues, and we performed the screening analysis that we are talking about here. It was not a licensee, per se. It was that we got a contractor and went out and did the work ourselves.

DR. ROSEN: What does the operating experience tell you? We have had a hundred plants running for 20 or 30 years, but we have never had one of those obviously.

MR. JONES: Right. None of these endstates has been experienced in the industry to date. There have been long term loss of coolant events, on the order of 24 hours, or more, but those were at times when the heat load in the spent fuel pool was such that -- well, loss of coolant events have been relatively limited.

We did look at issues such as what occurred at Connecticut Yankee, and also we considered the freezing event at Dresden, which was resulted in Bulletin 94-01.

And although it didn't directly involve a spent fuel coolant system, it was identified at that time that there was a vulnerability to a rupture in the spent fuel coolant transfer line that could have drained the spent fuel pool at Dresden Unit 1. But to answer your question though --

DR. ROSEN: That no operating experience would contradict this conclusion.

MR. JONES: Right.

MR. HUBBARD: This is George Hubbard again from Plant Systems. Right in this same time period, AEOD did a study that looked at operating experiences for temperatures and of the height or the level of the water level, and the water level dropped.

I was just glancing through here as you were talking, and it looks like there were a few in which the duration of the loss of coolant was like three in greater than 24 hours, in which the loss of coolant lasted for longer than 24 hours.

As far as the temperature increase, there was one time where it got to 50 degrees, and this was looking at our operating experience, and when we were doing this, we were aware of this data as this report was in early '97, and we completed the plant specific backfits.

And a report to the Commission went up in September of '97. So the operating experience was available to us, and I have not found the exact probabilities that they used from the AEOD experience.

But that was taken into account, the operating experience, and your comment that the operating experience doesn't contradict this is true.

DR. KRESS: Let me ask you about your two screening goals. It basically implies that if you meet these goals that you would meet the Commission's safety goals, and there is an order of magnitude of difference between these two, and the second one still meets the safety goals because during that time period you have operator action that could mitigate it so that you could get another factor of 10 out of that.

MR. JONES: Right.

DR. KRESS: Is that a correct interpretation?

MR. JONES: Yes.

MR. DIEC: We take into consideration a voluntary action as well and operator actions in this phase.

MR. JONES: These were essentially selected as more easily modeled endstates.

DR. KRESS: Oh, yes. If you go any further than that, then you have lots of physics. And if you don't meet these, there is no reason to go ahead.

MR. JONES: And also the difficulty in assessing the probabilities of recovery when the time frames get out to an order of a day or more.

DR. BONACA: So here the criteria is 8 hours? So as long as you can recover before 8 hours of boiling that's a success?

MR. JONES: Right. If it is extended

beyond 8 hours, then it is a questionable recovery.

MR. LEE: This is Sam Lee again. If I may add, the reason behind estimating the frequency of sustained blowing, if you remember back in the early '90s with the Susquehanna situation, where a boiling pool could affect the ECCS of the other units.

And that was the basis for why we conducted this analysis. After we did the analysis, or when we went to the plant as George said during the analysis, we found or discovered the physical layout of the plant was such that it was not like Susquehanna.

That even if you had sustained boiling, that the steam environment would not impact the ECCS of the other units. So it really became a non-issue for us at that point.

CHAIRMAN APOSTOLAKIS: Do you remember what the dominant contributors to these were? Were they seismic events?

MR. LEE: Yes. A seismic event is one of the major contributors, yes.

DR. ROSEN: When we talked about decommissioning plants, we talked about loss of spent fuel pool coolant events, and we were told at that time that the two most likely sequences to get there were seismic and sabotage.

MR. LEE: I will talk about one particular plant that we have data for, and the loss of inventory -- and this is through a break in the pipe -- was one of the dominant contributions, and the other one is the earthquake.

CHAIRMAN APOSTOLAKIS: Okay. Why don't we go on.

MR. DIEC: Well, at this time, I am going to turn it over to Steve Jones, who will discuss the basis for closure.

MR. JONES: As you are aware the staff completed a study of the events of the decommissioning of plants, and that study established a pool performance guideline regarding the frequency of events leading to a potential fire in the spent fuel pool or really fuel uncovery at 1 times 7 to the minus 5 for reactor year.

Using a source term that included consideration of large releases of Ruthenian and fuel fines, the staff evaluated consequences for a pool with approximately 30 days of decay from the most recent discharge.

That study demonstrated that the quantitative health objectives were met for then frequencies below the plant performance guideline, both in terms of prompt fatalities and latent cancer fatalities.

Since the screening criteria that were used in the plant specific studies were more conservative than the pool performance guideline of the decommissioning study, we considered that that would demonstrate that the quantitative health objectives were met for all the plant specific issues that were evaluated.

DR. KRESS: Let me ask you a simple question about that. The previous study with the NUREG 17-38 was dealing with decommissioning plants that didn't have a reactor there.

MR. JONES: That's correct.

DR. KRESS: So only the risk associated with the suppression pool had to be met in order to meet the safety goals. Now you are talking about a subset of sequences at an operating plant.

And it is not appropriate to say that the subset has to meet the safety goals, because safety goals have to be met by the pool summation of all the sequences.

So when you say it is an order of magnitude less than this screening criteria, I consider that appropriate, an appropriate choice. It is not overly conservative. It is an appropriate choice for a subset of sequences.

So I would not want to see you go up to 10 to the minus 5, for example, and say we will use that, because this is for an operating reactor, and you have to keep it down so that it adds in to the other risks. That was just an observation and a comment.

MR. JONES: I understand your point. We concluded that additional screening criteria were not necessary and that as Dr. Kress mentioned the absolute frequency values were roughly on the order of a magnitude lower.

And in addition the endstates were substantially more conservative, and the pool performance guidelines looked at a complete loss of inventory in the fuel pool, and our endstates were stopped at either sustained boiling or loss of a significant inventory, but still the fuel being covered. That concludes our briefing.

DR. KRESS: Are there any comments or questions that the Committee has? Seeing or hearing none, I think you made your case clear, and we will have a letter on the subject. And you brought us back on schedule, and thank you for the presentation. It was short and sweet and to the point, and we appreciate it.

CHAIRMAN APOSTOLAKIS: All right. Thank you.

(Whereupon, the meeting was recessed at 3:50 p.m.)

CERTIFICATE

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

Name of Proceeding: 486th ACRS Meeting

Docket Number: (Not Applicable)

Location: Rockville, Maryland

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.

Paul Intravia

Paul Intravia
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