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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

539TH MEETING

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THURSDAY, FEBRUARY 2, 2007

VOLUME II

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The meeting was convened in Room T-2B3 of Two White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 8:30 a.m., DR. WILLIAM J. SHACK, Chairman, presiding.

MEMBERS PRESENT:

WILLIAM J. SHACK, Chairman

JOHN D. SIEBER, Vice Chairman

SAID ABDEL-KHALIK, Member

GEORGE E. APOSTOLAKIS, Member

J. SAM ARMIJO, Member

SANJOY BANERJEE, Member

MARIO V. BONACA, Member

MICHAEL L. CORRADINI, Member

THOMAS S. KRESS, Member

OTTO L. MAYNARD, Member

DANA A. POWERS, Member

GRAHAM B. WALLIS, Member

STAFF PRESENT:

ZENA ABDUALLY
WILLIAM H. BATEMAN
GARY HAMMER
CORNELIUS HOLDEN
MICHAEL JUNGE
RALPH LANDRY
TIMOTHY R. LUPOLD
RALPH MEYER
BOB RADLINSKI
TANEY SANTOS
TED SULLIVAN
JENNIFER L. UHLE
SUNIL WEERAKKODY

ALSO PRESENT:

JOHN ALVIS
MICHAEL C. BILLONE
BERTRAND DUNNE
NAYEM JAHINGIR
CHRISTINE KING
ALEX MARION
ODELLI OZER
JIM RILEY
MIKE ROBINSON
GLENN WHITE

I-N-D-E-X

P-R-O-C-E-E-D-I-N-G-S

(8:33 a.m.)

6) OPENING REMARKS BY THE ACRS CHAIRMAN

CHAIRMAN SHACK: The meeting will now come to order. This is the second day of the 539th meeting of the Advisory Committee on Reactor Safeguards. During today's meeting, the Committee will consider the following: Proposed revision to 10 CFR 50.46 LOCA criteria for fuel cladding materials; draft final revision 1 to regulatory guide 1.189 (DG-1170), "Fire Protection for Nuclear Power Plants," and SRP section 9.5.1, "Fire Protection Program"; subcommittee report on ESBWR PRA; Wolf Creek pressurizer weld flaws; proposed revisions to regulatory guides and SRP sections in support of new reactor licensing; future ACRS activities and report of the Planning and Procedures Subcommittee; reconciliation of ACRS comments and recommendations; and preparation of ACRS reports.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Mr. Taney Santos is the designated federal official for the initial portion of the meeting.

A transcript of portions of the meeting is being kept. And it is requested that speakers use one of the microphones, identify themselves, and speak with sufficient clarity and volume so they can be readily heard.

I remind members that we are scheduled to interview two candidates during lunchtime today. Hopefully we'll stay on schedule and actually be able to eat lunch also.

Our initial item this morning is the work on the 50.46 fuel clad criteria. And since I have a conflict of interest on that, Jack Sieber will be running this portion of the meeting.

VICE CHAIRMAN SIEBER: Okay. Thank you, Mr. Chairman.

7) PROPOSED REVISION TO 10 CFR 50.46 LOCA CRITERIA FOR FUEL CLADDING MATERIALS

VICE CHAIRMAN SIEBER: And, without further ado, I would like to introduce Jennifer Uhle to provide the staff's introduction to the presentation on 50.46 this morning.

Jennifer?

MS. UHLE: Thank you. Good morning.

MEMBER ARMIJO: Mr Chairman, we did have a subcommittee meeting earlier. And maybe I could give you a little bit of a briefing.

VICE CHAIRMAN SIEBER: Why don't you take charge of this session?

MEMBER ARMIJO: It's okay with me.

(Laughter.)

VICE CHAIRMAN SIEBER: Okay.

7.1) REMARKS BY THE SUBCOMMITTEE CHAIRMAN

MEMBER ARMIJO: I just wanted to say that we did have a full day of subcommittee meeting on the 19th. Several members of the Committee were present. And we covered this topic in some depth.

We had presentations, of course, from the staff and from Argonne National Laboratory as well as presentations from Westinghouse, AREVA, and G&F on the issue of the phenomenon. As we have learned at the Committee meeting, it's complicated. It's a complex phenomenon going on.

The staff has done and research people done an admirable job in the research to try and understand these various components. There has been generally very good support from industry to this program, but the industry people have been reluctant to support use of the embrittlement criteria at this point because they believe the research is not yet complete. And the way to incorporate those research results into a rule is still not settled.

So we will be hearing today from both the staff and industry. And I think the time was allocated roughly about 50/50 to give everybody a chance to make their points.

With that --

CHAIRMAN SHACK: Go ahead.

MS. UHLE: Thank you. Good morning.

7.2) BRIEFING BY AND DISCUSSIONS WITH REPRESENTATIVES OF THE NRC STAFF

MS. UHLE: My name is Jennifer Uhle. I am the Deputy Division Director for Materials Engineering in the Office of Nuclear Regulatory Research.

I would like to thank the Committee for taking the time to meet with us today to talk about our research program dedicated to the development of revised fuel clad acceptance criteria for postulated loss-of-coolant accidents. Of course, these famous criteria of 2,200 degrees Fahrenheit and 70 percent local clad oxidation are contained in 10 CFR 50.46.

Today we will try to describe to you our understanding of these complex phenomena that contribute to the embrittlement of fuel clad under these conditions.

This understanding has been developed over a period of ten years. And we will do our best to summarize it in the time allowed. To facilitate our communication, we will be providing a set of proposed acceptance criteria. But I want to stress that today we are not presenting to you rule language. And that will be developed at a later date in NRR along with research support as well as stakeholder involvement.

We feel there is a great need for a revision to the present rule for a variety of reasons. First, the current criteria are non-conservative. The NRC has managed this issue of ensuring plants are taking voluntary measures to ensure safety in the event of a LOCA.

Second, we have shown that the criteria are affected strongly by burnup as well as a choice of alloy and even fabrication process.

Third, the current rule is written to be clad-specific. And licensees are required to get exemptions from 50.46 to be able to use the new and better-performing clads. We find this to be unnecessarily burdensome to the licensees and, more importantly, to the staff because we're spending our time reviewing these submittals. And, of course, the need for exemptions may also be hampering the introduction of superior clad materials.

So research believes this program has

generated a sufficient amount of data to proceed with the rulemaking in one presentation. In Ralph Meyer's presentation, you will see that there is one prominent area deemed the F factor, some of it citing, where we have data but we have also used some judgment to provide the basis for our proposal.

Our research believes that proposed criteria will ensure safety. And it's important to go forward with the rulemaking, one of the concerns I previously mentioned, although you will hear from the industry. I think other stakeholders desire to postpone the rulemaking to provide more of a database.

Our goal today is to try to convince you to support our decision and our goal to move forward with the rulemaking. We look forward to hearing your views. If there are no other questions about what we're trying to accomplish --

MEMBER ARMIJO: Real quick one. If you went ahead with this, what is your time frame in which you would actually have wording that would go into the rule?

MS. UHLE: Well, we have a NUREG. Research has the NUREG. And we're writing them. And it's hoping to finish it and transfer it over to NRR the end of March time frame. Then the NRR has, of course, a rulemaking schedule developed that involves certainly the legalities of rulemaking, which is stakeholder involvement.

The current rulemaking, at one point the rulemaking plan that was developed a year ago indicated that the final rule would be out on the street January 2009, so early January 2009, so a few years from now.

Right now the Commission, of course, requested the staff to prioritize the rulemaking activities. And with this realization of the non-conservatism of the current rule, the staff is questioning whether or not we need to prioritize this higher and perhaps expedite.

Ralph Landry, do you want to add anything to that? Ralph Landry is NRR. He would be in charge of the rulemaking activities.

MR. LANDRY: Ralph Landry, NRR. I'm not in charge of rulemaking activities.

MS. UHLE: You're in charge of the technical aspects of rulemaking activities.

MR. LANDRY: The point of what Jennifer said is very accurate. We have not initiated the rulemaking at this point. We are following very closely. We have been very involved in this work with the Office of Research. We would like to proceed in a very orderly fashion to a new rulemaking, to changing the acceptance criteria.

We have had acceptance criteria in 50.46 that have withstood 30-plus years of use. And as we move forward, I want to make sure that we proceed to criteria that would withstand another extended period of time that we would not need to go back and change in a very short time.

And we're looking at it a couple of different ways. This was brought up at the subcommittee meeting. Could we put performance-based words into the rule and details in a regulatory guide or do we have to put some details into the rule? We haven't pursued exactly the legalities of which approach to take at this point, but it is very appealing to have performance-based words in the rule itself and the details left to a regulatory guide.

MEMBER ARMIJO: Thank you.

MS. UHLE: Okay. So if that is all, then, I would like to introduce Dr. Ralph Meyer from the Office of Research, who is the lead technical staff member in charge of the research program.

In addition, Dr. Billone, who is the principal investigator from Argonne. He is also here if you have any particular questions you'd like to ask.

DR. MEYER: Good morning. We've been working on cladding and fuel response to loss-of-coolant accident conditions for almost ten years now and have had a fair amount of cooperation that I want to mention. The industry has had us in this program.

(Pause.)

MEMBER ARMIJO: Okay. We're ready to go. Ralph, our apologies.

MEMBER APOSTOLAKIS: Who is the person on the other side?

DR. MEYER: That will cost you five minutes.

PARTICIPANT: Can we ask who else is on the bridge right now?

PARTICIPANT: Westinghouse. I'm going on mute now. Thank you.

PARTICIPANT: Thank you. Sorry about that.

DR. MEYER: Okay. We've had cooperation from the industry. I want to mention quickly that EPRI has been involved with us from the beginning. Global Nuclear Fuel, AREVA, its preceding companies, and Westinghouse have all provided fuel rods and fuel cladding materials for testing in the program. And they have been very free to give us their opinions as well.

In addition to that, I want to mention another program that I sometimes forget to mention in doing this work. And that's a program that we have had with the Kurchatov Institute in Moscow.

The French IRSN and the NRC for almost the same number of years had been providing some support to Kurchatov to do related work. And they have done almost a parallel study to what we have done up at Argonne National Laboratory and documented that in a NUREG IA report that we issued almost two years ago.

This is very extensive and unraveled some of the pieces of the puzzle that we will talk about today. So I want to mention the Kurchatov work and IRSN support work. And I also want to mention the Russian fuel manufacturer, Tivel, is also a sponsor of this work and, in fact, probably paid the lion's share of the cost, although we ran the content of the program from this little international arrangement that we had.

Now, the work at Argonne has been documented in a draft NUREG CR report, which I think the Committee has. We sent it to the Committee. It's a fairly lengthy report. And we spent a lot of time talking about that at the subcommittee.

So there are a lot of things that happen to the fuel during a loss-of-coolant accident. And our research has looked into a number of them but has focused primarily on the loss of ductility that takes place in a process that we just generally refer to as embrittlement.

During a loss-of-coolant accident, the cladding temperature goes up. And somewhere in the vicinity of 800 degrees Centigrade, the cladding softens. It balloons. It pops. It ruptures. It relieves the pressure. It also goes through a phase change just about at the same temperature. They're not totally related to each other, but they do happen at about the same time.

Now, only above that temperature, starting at around 900 degrees Centigrade does the oxidation rate on the surface because it's in steam, the surface oxidation rate, picks up enough that you will accumulate a lot of oxidation during the period of the transient.

And at the same time, the oxygen that is laid on the surface begins to diffuse into the metal.

Then eventually the cooling water from the emergency cooling systems comes in, cools, and quenches the material. Then it goes back through the phase change.

The low-temperature phase change we refer to as the alpha. The high-temperature one is the beta phase. And I'll come back to that in just a second.

Now, the current embrittlement criteria you're probably all familiar with this. It's in 10 CFR 50.46, part B. In paragraph 1, there's a temperature limit of 2,200 degrees Fahrenheit. That's 1,204 degrees Centigrade. And we will just glibly speak of 1,200 degrees Centigrade in the presentation.

There is an oxidation limit of 17 percent. This is really a time limit because it was understood at the beginning and we know it now that the embrittling process does not take place on the surface where the oxide is accumulating. It is related to the diffusion of oxygen in the metal.

The diffusion process and the oxidation process run at about the same speed. And so an oxidation limit was used. It's very convenient. I won't go into the details, but it turns out to be a very convenient thing to do. It gives you a nearly constant number that you can use as a limit.

In running a LOCA calculation, you

calculate -- well, your basic LOCA transient calculation is just time and temperature. And then you run along with that some equation for oxidation and get a calculated oxidation amount during the transient. And you keep that less than 17 percent, less than or equal to 17 percent.

One-sided oxygen pickup is assumed everywhere along the cladding except in the balloon. And in the balloon, you recognize that you have hit a rupture. And the steam can get into the inside of the balloon and lay oxide on the inside. And then oxygen will diffuse in from the inside simultaneously with the diffusion in from the outside. So you use a two-sided assumption within the balloon.

In 1998, after we became concerned about the effects of burnup on these criteria, NRC issued an information notice that clarified the 17 percent number. And we said at that time the 17 percent was total oxidation, meaning the transient oxidation plus any corrosion that accumulated on the fuel rod during normal power operation.

Now, in the next ten slides, I want to just give you a brief overview of the type of work that's been done to support the criteria that we're going to describe to you later on.

This is work that Mike Billone spent three hours describing to the subcommittee. I'm going to spend about three minutes on it literally. I just want to give you a feeling for the magnitude of the experimental program that has been undertaken.

So, first of all, here is a list of all of the cladding materials that we have tested, Zircaloy-2, 4, ZIRLO, M5, and a Russian E110. And in some cases, we have had multiple subsets of these. Zircaloy-4, for example, we have three distinct varieties of Zircaloy-4. We have some older vintage 15 by 15 Zircaloy-4, some modern 15 by 15 Zircaloy-4, and some modern 17 by 17 Zircaloy-4, in addition to having the high burnup Zircaloy-4 of the older variety.

MEMBER BANERJEE: What do you mean by "15 by 15," "17 by 17"?

DR. MEYER: The fuel geometry, the --

MEMBER BANERJEE: Oh, the bundles, yes.

DR. MEYER: -- bundle size. And the geometry turns out to be important because the more rods in the array, the thinner the cladding. And you're going to see that cladding thickness shows up in one of the equations. And so it has a direct effect on embrittlement.

So we have looked at all of those materials. We have a furnace that is radiant-heated. It has reflectors and a central tube going down through there with a specimen. We can use short specimens. We can use long specimens. We can pass steam over the outside only. We can pass it up through the middle and the outside. All of those kinds of tests are done in this apparatus.

MEMBER POWERS: Ralph, you indicated in your introductory comments that most of the period of time you're interested in, rapid oxidation is not taking place. Did you have to get up to above some critical temperature before you get rapid steam oxidation in the cladding?

DR. MEYER: Yes.

MEMBER POWERS: That means in the real reactor accident, the heat is coming from the inside out to the clad. But in your experiments, you're going from the outside in on the clad. Does that make a difference?

DR. MEYER: Actually, most of the testing that we have done has been two-sided. And so there was a time when we were concerned that by doing so much of the work with two-sided oxidation, that we were not setting the test up right. And we did then do some one-sided oxidation tests.

In the end, as you saw and the rest will see, we're going to suggest that the two-sided analysis be done everywhere on the run so the tests are exactly the right ones for that.

MEMBER POWERS: Thank you.

MEMBER BANERJEE: So typically in a bundle, at these temperatures, some portion of the heat is coming from radiation onto the surface in some form inside. What is that fraction?

DR. MEYER: The heat source is --

MEMBER BANERJEE: Inside, but it's radiating, right, as well?

DR. MEYER: Well, but, I mean, you just have similar rods all around. So they're all --

MS. UHLE: This is Jennifer Uhle from the staff. I mean, that's hard to say. It depends on the transient. It depends on exactly the view factors, the peaking factors because obviously you need the strong delta-T to provide the driving force.

I think being from NRR, when I was in NRR, review maybe at most 20 percent, I think is from radiation at the real high temperatures. But that's when you're up at the --

DR. MEYER: The two main heat sources are the heat from the inside coming from decay heat and stored heat from the beginning of the transient and then the heat from the metal-water reaction. And those are all accounted for in the analysis.

So temperature is a very important. This metal-water heat affects the temperature rise during the transient. So in setting up the experimental apparatus, a lot of effort is put into calibrating the furnace and the temperatures on the rods to be tested.

That picture looks so good on the file. Anyway, the main test that we do is a ring-compression test. You can hardly see it here, but there is an Instron machine that's squeezing a --

MEMBER POWERS: It is much better in the handout.

PARTICIPANT: The handout is good.

DR. MEYER: -- the ring of the cladding that's about eight millimeters long. We have a couple of Instron machines doing this. One is in a glove box where we can squeeze irradiated pieces. And one is just sitting out in a laboratory where it's easier to get to.

The ring-compression test results have to be interpreted. Our techniques for doing this are much more sophisticated than they were back in 1972 and 1973, where the same ring compression, general ring compression, technique was used. And so we know how to do this quite well now.

The furnaces are generally programmed in a way that more or less represents the temperature rise during a postulated accident.

MEMBER APOSTOLAKIS: Ralph?

DR. MEYER: Yes?

MEMBER APOSTOLAKIS: It may be obvious to a lot of people here, but where are you going with this? What are you trying to get out of these experiments?

DR. MEYER: All I want to do at -- what we're trying to get at are criteria that can be used to identify when the cladding loses ductility during this transient so you can use that as a limit and then with that limit show that the emergency core cooling systems have been adequate to protect the ductility of the material.

MEMBER APOSTOLAKIS: So when do you mean the time? How long it will take to lose ductility?

DR. MEYER: Well, that's basically what we determine experimentally.

MEMBER APOSTOLAKIS: Right.

DR. MEYER: And then that information is

contained in the temperature limit and the oxidation limit and applied in the analysis, the safety analysis, when you analyze the thing.

VICE CHAIRMAN SIEBER: Those limits are surrogates for the loss-of-coolable geometry, which is the endpoint. You want to maintain coolable geometry.

DR. MEYER: Endpoint is loss-of-coolable geometry. There were big discussions about this during the hearing in 1972 and 1973. It came down to a position of maintaining ductility in the cladding as the way to ensure a coolable geometry.

And we have not tried to change any of the underlying philosophy or the basic experimental approach to it but just do it in such a way that we can see the effects of burnup and manufacturing variables and update the criteria.

We were able to do four what we call integral tests on high burnup rods before we lost access to the alpha-gamma hotcell at Argonne. And these are pictures of those four. All four of these fuel rods were BWR fuel rods with low corrosion. And you can see the single balloon and ruptured area in each of those.

We analyzed those in detail.

MEMBER ARMIJO: Ralph, I'm sorry. You

didn't do the H. B. Robinson? Didn't you do an H. B. Robinson?

DR. MEYER: We didn't get to the H. B. Robinson before the --

MEMBER ARMIJO: Before they shut down?

DR. MEYER: -- hotcell was shut down. So we have the specimens. And we want to test them. But we have had no ability to do that since July 26, 2005.

MEMBER ARMIJO: Okay.

DR. MEYER: We remember the day.

MEMBER ARMIJO: And you also have the M5 fueled rods and the ZIRLO?

DR. MEYER: No, no. It's a very painful process to get fuel rods from a power plant for testing. And over the years, we have been able to get a set of BWR rods from the Limerick plant and a set of PWR rods from the Robinson plant. These are relatively older fuel types.

We have plans to get ZIRLO-clad rods and M5-clad rods with high burnup for this program. Those rods have not been provided yet. So those are not in the current test program.

What we were able to get were some small pieces of M5 and ZIRLO cladding from high burnup rods, getting those pieces from the Skuzda Laboratory, where they had such fuel rods for testing and we made arrangements to get those pieces. Those pieces have not been tested yet either but will be tested hopefully in the next two months.

DR. BILLONE: Excuse me. This is Mike Billone from Argonne. Just for clarification, the high burnup M5 rods that we and EPRI have agreed to put into the program are in transit to Argonne. They have been in transit for six months, but they're in transit.

PARTICIPANT: Slow truck.

DR. BILLONE: Slow truck.

MEMBER ARMIJO: But you physically have the H. B. Robinson rods, --

DR. BILLONE: Yes, yes.

MEMBER ARMIJO: -- even though that's an old vintage --

DR. BILLONE: Correct.

MEMBER ARMIJO: Okay.

DR. OZER: Excuse. This is Odelli Ozer, EPRI. The M5 rods have been shipped. They're at the Idaho National Laboratory. They're just awaiting shipment from Idaho hotcell over to wherever Argonne wants them.

And we are in discussions with

Westinghouse for ZIRLO rods.

DR. MEYER: Well, since we've gotten onto this subject, let me say that we have had a program plan for this program since 1998. It was updated in 2003. It has been reviewed by the subcommittee and by the full Committee several times.

In that program plan, we always knew that we would not have the high burnup ZIRLO and M5 rods in time in the time that we wanted to try and revise the embrittlement criteria.

And so the plan for the beginning was to examine unirradiated rods of Zircaloy-2, Zircaloy-4, M5, and ZIRLO and irradiated Zircaloy rods. With this cut of the variables to make an assumption that the burnup effects that you saw in the Zircaloy would apply to M5 and ZIRLO because we realize that we wouldn't have those rods in any timely way to make the test. And that turned out to be the case.

So what we're going on here are burnup effects measured on Zircaloy and, by assumption, carried over to M5 and ZIRLO with the alloy and manufacturing properties measured on the unirradiated material.

I think we understand enough of what is going on that this is a reasonable approach. And I hope that I can convince you of that. Sometimes if we want to do a mechanical test in the balloon, instead of cutting a ring and compressing it because of the deformation, we do a bending test.

And we do a lot of microscopy to look at the details of metallurgical phases in the oxide layers that build up on the rod. This happens to be a scanning electron microscope picture. We do a lot of optical microscopy also.

Okay. So that was my three-minute sweep through the experimental program. Now what I want to do is to slow down and talk about what is really happening and what we have learned from the results and then how we propose to use those results.

So imagine that a fuel rod has been through a temperature transient such as the one that I showed and has now been cooled back down to near room temperature and you look to see if it's brittle or ductile.

So what you see when you look at the sample is that there is O_2 on the surface, oxide on the surface, and then you see material that when it went up in temperature had all transformed to the beta phase. But as oxygen diffused into the metal from the oxide that's lying on the surface, the oxygen concentration in the beta phase got above the solubility limit and caused it to go back to the alpha phase, which had a lot of oxygen in it.

And so when you take it all back down to room temperature, what you see is a region that was in the beta phase at high temperature. You clearly see this oxygen-stabilized alpha layer. And, of course, you see the oxide layer.

Among these phases, the only one that has any ductility is a portion of the prior beta phase. It's the portion of that phase that has a low oxygen content, a content lower than about six-tenths of a percent of oxygen.

VICE CHAIRMAN SIEBER: Could you tell us which phase is body-centered cubic and which is --

DR. MEYER: Yes.

VICE CHAIRMAN SIEBER: -- phase-centered?

DR. MEYER: Yes, I can. The low-temperature alpha phase is a hexagonal close-pack structure. And the high-temperature beta phase is a body-centered cubic.

When the original work was done in the late '60s and early '70s and the rule was first written, there was this Appendix K that you are probably all familiar with. Appendix K required that you use the Baker-Just oxidation equation.

And that was because the data that Hobson had taken, which were used as the basis for the 17 percent number, had been reduced with the Baker-Just equation. Hobson did not measure the amount of oxidation. He calculated it with Baker-Just. So he used Baker-Just going in. He used Baker-Just coming out. And it worked.

We're switching from the Baker-Just correlation to the Cathcart-Pawel correlation because it's a much more accurate correlation. And I just wanted to put in your handout the equations that we're using so that they would be for reference. I don't think I need to talk about those in any detail.

MEMBER ARMIJO: Ralph, I just want to ask one question and just to be sure. Have you confirmed or is it well-known that the oxidation kinetics for the, let's say, various types of zirconium alloys, Zircaloy-2, 4, M5, and ZIRLO, have the same activation energies and pre-exponentials so that this one equation represents the whole family?

DR. MEYER: Yes. We have confirmed that they don't.

MEMBER ARMIJO: Okay. Confirmed that they don't. So would you use a different equation for each if you're --

DR. MEYER: Okay. I really need to explain this. And I know I ought to do this. The Cathcart-Pawel equation works very well for all of the alloys we have tested, the ones you have mentioned: Zirc-2, Zirc-4, M5, and ZIRLO, at the high temperature end of the range of interests. At 1,200 degrees Centigrade, a Cathcart-Pawel works quite well for all of them.

As you go down in temperature, particularly the M5 alloy, which has no tin in it, it's just zirconium-1 niobium, it has slower oxidation kinetics, say, around 1,000 degrees Centigrade. It's much slower.

Now, by using the Cathcart-Pawel equation, even for M5, we're not introducing any error into the situation because it's just the parameter that we correlate against. It's our surrogate for time. So it does not represent the true oxidation rate for M5 at lower temperatures, but it is still a good time yardstick.

MS. UHLE: This is Jennifer Uhle.

MEMBER POWERS: Couldn't you just stick with Baker-Just, then?

DR. MEYER: We could have used Baker-Just.

MS. UHLE: This is Jennifer Uhle from the staff. We just want to point out that in the regulatory guide or perhaps in the ruling, which when it gets worked out will be the guidance to make sure that whatever correlation or whatever equation, oxidation equation, you're using to reduce your data to show when you lost ductility, you have to use that in your system analysis code that will tell you what your fuel rods would be, how brittle they would be during a loss-of-coolant accident.

So right now there is a disconnect because in the 17 percent limit currently, that was derived using Baker-Just. However, in best estimate methods that the licensees have and vendors have been using for they have NRR approval to use, they're free to use whatever correlation is acceptable for the oxidation equation.

So there is currently a disconnect. Now, thankfully it's not that much in error, but in the future, we need to make sure that those two are consistent.

MEMBER CORRADINI: Just to clarify because you tried to explain it. I thought I got it, but now I don't have it. So let's just stick with Cathcart-Pawel. And you were to take a set of data.

So you said this is just a surrogate for time. So what you're using this for is to compute a percent reaction given the protocol, which is if it's not ballooned, it's one-sided. If it's ballooned, it's two-sided and then with that percentage, then come back to a time.

I'm still not clear about that because what you said about M5, I remember being the case. I'm not exactly sure how it still sounds to me like using Cathcart-Pawel. With a range of temperatures as you cook the fuel, you're going to overestimate oxidation.

DR. MEYER: You will overestimate oxidation for M5, for example, because it spent some time at a lower temperature. But, as it turns out, the oxidation process doesn't control the embrittlement process. It's diffusion into the metal that controls the embrittlement process. So we're just using oxidation rate as sort of a surrogate for diffusion rate because we can measure it.

MEMBER CORRADINI: I understand. May I just ask, then, the obvious question? So if I overestimate oxidation and it's a surrogate for diffusion, why am I not also overestimating the diffusion time and, therefore, overestimating the embrittlement?

DR. BILLONE: Ralph, can I --

DR. MEYER: Help me out, Mike.

DR. BILLONE: No. Let's look at it a different way. If I test M5 at 1,200 degrees C. and Zirc-4 at 1,200 degrees C. or 1,000 degrees C. -- let's go to the 1,000, where they're very different -- they pick up weight, oxygen, at different rates, but they embrittle at about the same rate because what's controlling is a diffusion process of oxygen into the metal and through the metal.

So M5 forms a thin oxide layer. Zirc-4 will form a thick oxide layer, which doesn't contribute at all as long as you have an oxygen source there to drive your diffusion.

The simple fact is when you plot M5 ductility goes down like that with time versus Zirc-4 ductility, which goes down. They go down at the same level.

MEMBER CORRADINI: So one last question, and then I'll be quiet, which is then the oxidation kinetics is nothing. You are using the A and the Q and the R essentially as a solid diffusivity model, which is approximately right, regardless of the oxidation.

MEMBER BONACA: Right.

MEMBER CORRADINI: Okay. Fine.

DR. MEYER: Now, I want to point out that you would not want to do this in calculating the metal-water heat, the separate matter. The metal-water heat you would want to use a best estimate oxidation correlation. But for us it turned out to be convenient just to use this same calculation, plot all of our data not as a function of time but as a function of what we call CPECR, Cathcart-Pawel Equivalent Clad and Reactive.

MEMBER ABDEL-KHALIK: Would you expect this to work for any and all yet-to-be-developed alloys?

DR. MEYER: I expect this to work for any and all zirconium-based alloys that are in the tin niobium family at the concentrations of around one percent; in other words, the range of things we --

MEMBER ABDEL-KHALIK: And this is --

DR. MEYER: We tested all the way from zirconium-tin to zirconium-niobium. Anything in that range I believe these results will be applicable.

MEMBER ABDEL-KHALIK: And this expectation is based on what? Intuition?

DR. MEYER: It's based on testing that

wide variety of materials that are in this range which have not only differences in composition but also differences in fabrication and understanding which differences cause some change in the ductility behavior and arranging the criteria in such a way that it would catch all of them.

MEMBER BANERJEE: A couple of questions. What is that 87.8 there?

DR. MEYER: It's just a geometric factor. Let me define equivalent cladding. There are four hours of details involved in this subject at least. Equivalent cladding reacted is where you can do a calculation and you assume that all of the oxygen that is consumed goes into ZrO_2 at the surface. And none is lost by diffusion into the metal.

That's what ECR is. It's a concept that was used 35 years. There's nothing wrong with the concept. And we stick with it, with the concept.

MEMBER BANERJEE: What is it? It says it's 20 percent oxidized or something, 17 percent? What does that sort of pertain to?

DR. BILLONE: It pertains to the fraction of the wall thickness that you consume.

DR. MEYER: The temperature of the time and the wall thickness, yes.

MEMBER BANERJEE: Thank you.

MEMBER ARMIJO: Okay.

MEMBER APOSTOLAKIS: Now, this temperature, Ralph, which temperature is this peak? Is that time-dependent as well?

DR. MEYER: Yes.

MEMBER APOSTOLAKIS: Big T. That's time-dependent?

DR. MEYER: Yes.

MEMBER APOSTOLAKIS: So time is varied in T as well?

DR. MEYER: Yes, yes.

MEMBER APOSTOLAKIS: Okay.

DR. MEYER: So you do the calculation. And you, just like that first slide that I showed you, have temperature running along with time and changing. And you can in the models integrate the amount of oxidation that takes place, which is a good surrogate for integrating the amount of diffusion that takes place because they have the same kinetics and roughly the same coefficients.

Okay. The first and main result that we see is that, sure enough, the high burnup material embrittles in less time; that is, at a lower calculated oxidation level, than the fresh material.

So what you have here is irradiated H. B. Robinson Zircaloy-4. It's 15 by 15. It's old vintage. It has a rough surface. And it is embrittling at around eight percent ECR, which is well below the 17 percent number that we have talked about.

Now, if you take very similar unirradiated material -- I'm not quite sure it deserves to be called archive material, but it's as close as we could get to archive material. So here we have this same vintage unirradiated 15 by 15 Zircaloy-4. And we test that. And it tests out at about 14 percent.

Now, just as a little matter of interest, this is with the Cathcart-Pawel model. If we had been using the Baker-Just report, Baker-Just equation, there's a 3 percent difference. It would be 17 percent. This is exactly what was tested, the result that was obtained in the early 1970s, on which the original rule was based.

MEMBER ARMIJO: Ralph, just so everybody knows, your ductility reference is two percent ductility. That's your target that you want to achieve.

DR. MEYER: Yes.

MEMBER APOSTOLAKIS: Okay.

DR. MEYER: Sorry. Sorry about that. I

have glibly used the word "ductility" here. We actually have two techniques that we use. One of them comes directly from the Instron machine, where we look at the displacement versus time and can get something we call an offset strain.

And the other method is actually simpler. You just measure the diameter of the ring with micrometers before you squeeze it and after you squeeze it, right at the point where you develop the first through-wall crack.

And in one case because of bending and other things that I don't understand but I hope Mike understands, in one case the zero is at one percent when you use micrometers and it's two percent when you're using this offset strained value that we measure.

MEMBER APOSTOLAKIS: So when you say, "high burnup" roughly --

DR. MEYER: High burnup. This had a burnup of --

DR. BILLONE: Sixty-seven.

DR. MEYER: -- 67 gigawatt days per ton. You can see that the specimen that was tested here had a corrosion thickness of about 80 microns. If you run the numbers and take 14 percent, convert 80 microns to equivalent cladding reacted as a percentage, multiply that by 1.2, which is the F factor, and subtract it from 14, you get 8.

So this is where the so-called F factor comes in. The reason that we didn't just say 1.2 right off the bat was before we made the measurement, we didn't know what the number was going to be. And so we just put a factor in the equation.

After we measured it, we found some sensitivity to heat-up rates and cool-down rates, which could cause this F factor to have several values.

So we have, in fact, explored the possible range of those values and, as a matter of judgment, selected 1.2 as the most appropriate value to use. This is the point where judgment has entered into the final result and where there can be some difference of opinion on what the F factor should be.

MEMBER BANERJEE: Could you just repeat what the F factor is?

MEMBER ARMIJO: He hasn't gotten there yet.

DR. MEYER: Wait for a couple of slides and let --

MEMBER BANERJEE: You keep saying "F

factor." And I don't know where it is. All right.

DR. MEYER: F is for factor. It's just a factor. Look, this is an empirical correlation. And what we're doing is we know that the main effect -- and I forgot to say it -- here is a result of hydrogen that gets absorbed into the cladding during normal operation as a consequence of the corrosion process. We know that about 15 percent of the released hydrogen gets absorbed into the cladding.

But I said before that oxygen was the embrittling agent in the material. And so what we believe is going on here is that the hydrogen is controlling both the solubility limits or it's altering the solubility limits and the diffusion rates.

So it's not necessarily doing any embrittling on its own because it's all in solution at the high temperature, but it is affecting the oxygen diffusion into the metal.

And on this slide, I simply show that we have confirmed that hydrogen is having this effect by taking unirradiated Zircaloy-4 and other materials, pre-hydriding them in the laboratory, and then testing them in the same way. And you can reproduce the effect by doing that.

MEMBER ARMIJO: Ralph, there is a contention that I want to give you a shot of answering before the industry folks talk that by virtue of quenching these materials from high temperature, you introduce a hydrogen embrittlement, in addition to the oxidation embrittlement, because that's an issue that is going to come up we'll have to wrestle with. Have you confirmed that the hydrogen effect is strictly oxygen or is it oxygen embrittlement plus hydrogen embrittlement?

DR. MEYER: Well, now, I think that there is a component of direct hydrogen embrittlement in the samples that have been -- is it the quenched ones or the slow-cooled ones? I get confused on this. But all of this is wrapped up in the cooling rate --

MEMBER ARMIJO: Right.

DR. MEYER: -- effect, which we have looked at and made some judgments about. Mike, do you want to --

DR. BILLONE: Yes. I would say most of that loss of ductility that you see is due to increase in oxygen. There's a small but significant -- in other words, if you're setting two percent as the limit, if you slow-cool the sample, you might get three percent ductility where you expect less than three.

And so essentially quenching freezes in hydrogen in solution in places where it causes embrittlement. So if you quench at 800 degrees C., your sample is going to be more brittle than if you just cool to room temperature with no quench.

MEMBER ARMIJO: Okay.

DR. MEYER: Okay. Now, the next big effect that we found in this study was actually noted first in some Eastern European tests that were done in the '90s. And we learned from what we did that this breakaway oxidation process had it been seen earlier, in fact, affects the embrittlement process.

So what happens with the zirconium alloys? And it can happen to all of them. It turns out that the old E110 Russian cladding was the most susceptible to this and provided the most dramatic pictures of it.

But what happens is that as you enter this high temperature region and you start laying down the oxide on the surface, that the type of oxide that we normally see is black and shiny. It's a tetragonal form. And it's rather protective and doesn't allow the hydrogen to enter in any significant amount during the period of the high temperature transient.

Under some conditions, this oxide can

switch from a tetragonal to a mono-clinic form. A mono-clinic form is not black and shiny. It's dull looking. It's full of micro cracks. And it lets hydrogen in.

And so as soon as you get into this break-away process, hydrogen starts getting sucked into the cladding and has the same effect as it had before. So you have to be careful with all of these alloys to make sure that you don't have the conditions that promote the bad oxide to grow.

VICE CHAIRMAN SIEBER: Is that flakes of oxide?

DR. MEYER: Yes, those were flakes. That was a very advanced case of stuff. I like that picture because of its dramatic effect.

MEMBER ARMIJO: Ralph, to be sure that everyone has some time, it might be a good idea to get to your proposed.

DR. MEYER: Okay.

MEMBER ARMIJO: It's 9:27. And we're supposed to wrap up at 10:00.

DR. MEYER: Okay.

MEMBER ARMIJO: Is that right, Mr. Chairman? So I think it's important that people understand your proposal.

DR. MEYER: Okay. Let me skip over these, then.

MS. UHLE: Why don't you talk about that one there?

DR. MEYER: I do need to talk about this one.

MEMBER ARMIJO: Yes. Okay.

DR. MEYER: Okay. So the concept is that diffusion of oxygen into the metal is the embrittling factor, not laying down the oxide on the surface. It turns out that you have a big source of oxygen on the inside of all cladding materials, UO_2 fuel full of oxygen.

And we know from our present work and from some historic work that we looked up that as soon as the cladding and the fuel stick together, that source of oxygen then becomes available for diffusion into the cladding.

I think we have incontrovertible -- is that the right word? -- evidence that this effect is real and it is at least when you have a bonded fuel layer, which you generally would have at high burnups, there is ample oxygen on the ID. So that you get diffusion from both directions, whether you're in a balloon or not in a balloon.

VICE CHAIRMAN SIEBER: That ample oxygen comes from the UO_2?

DR. MEYER: It comes from the UO_2. It comes from --

VICE CHAIRMAN SIEBER: I thought that was pretty tightly bound.

DR. MEYER: It comes from the UO_2. One other thing I need to point out -- and then I'll get right to the criteria -- is that within about an inch of the center of the rupture, you also have hydrogen absorption on the ID. You had steam getting in, oxidizing the inner surface of the cladding, where it can get in the balloon.

And, again, the oxidation process frees up hydrogen. And the hydrogen isn't swept away very readily. It's trapped inside. And so you get high hydrogen absorption in the vicinity of the balloon.

MEMBER BANERJEE: So does the oxygen diffuse through the oxide layers, oxide layer crack, and get through the reaction zone?

DR. BILLONE: No, no. What happens is you are getting oxidation in the opening, the balloon opening region.

MEMBER BANERJEE: I'm saying imagine you've got this bonded fuel or whatever.

DR. BILLONE: Right.

MEMBER BANERJEE: Oxygen is now diffusing through the oxide or are there cracks in the oxide and allows oxygen in?

DR. BILLONE: The steam oxygen is creating an oxide layer. And oxygen is also diffusing through that layer.

VICE CHAIRMAN SIEBER: Right.

MEMBER BANERJEE: From the inside?

DR. BILLONE: From the inside.

MEMBER BANERJEE: But when it's just bonded.

DR. BILLONE: Well, in the balloon, you have expanded 50 percent.

MEMBER BANERJEE: Right, right. Yes, we understand that.

DR. BILLONE: I'm trying to answer about the ID. I'm missing the point.

DR. MEYER: It is present on the surface, and it just diffuses in.

MEMBER BANERJEE: It diffuses in. It's not cracked.

DR. MEYER: No. It diffuses in.

MEMBER BANERJEE: Aren't there kinetics associated with that diffusion?

DR. BILLONE: That's the same kinetics.

MEMBER BANERJEE: It goes to teach us how?

DR. MEYER: I need to go through this. And then I think I'm where you want to be. So we get these high hydrogen concentrations, very high hydrogen concentrations, 3,000 ppm, the vicinity of the balloon.

The balloon does not stay ductile. It has some strength left, but in spite of the fact that the current regulation has detailed prescription on how to analyze the balloon, it really doesn't work because the balloon has hydrogen in it that wasn't realized when the rule was put together that causes the balloon to be -- let me go right to here. And I'll come back if I have to.

So here is what we are proposing to do. We're proposing to keep the temperature limit right where it is with no change. There's a lot of history with this. And there's also an effect that we see in the present work.

Once you get above about 1,200 degrees Centigrade, the oxygen diffusion rate picks up. And the oxidation limits would then be lower. And so you basically have more parameters here than you need.

And you can just fix this temperature

right where it has always been at 2,200 degrees Fahrenheit and then work the rest of the problem from there. So that is what we have done.

And now what we are looking for here is a replacement for 17 percent, which accounts for the effect of burnup. And so we will start with a measurement on unirradiated cladding at 1,200 degrees. And there's a reason for choosing the 1,200 degrees.

This is the analogue of 17 percent. I'll show you some values. And we subtract from that the corrosion thickness multiplied by a scaling factor, just an empirical factor, to fit the data.

MEMBER ARMIJO: Now, currently that factor is one, right?

DR. MEYER: Yes. If you were to use the information notice recommendation, that factor would be one. I have to tell you that at the time the information notice was written, we did not understand this process. It was a guess. We expected that there would be an effect, and it was a logical guess to make.

MEMBER ARMIJO: You have incorporated all burnup effects into that 1.2 times --

DR. MEYER: Well, not quite all because there is the matter of break-away --

MEMBER ARMIJO: Right. Okay.

DR. MEYER: -- that is accommodated by a separate limit. And then there is the matter of the two-sided oxygen penetration. All of these are accommodated by everything that is on this page, but the first line takes account of the basic burnup effect that is a consequence of corrosion and hydrogen absorption during normal operations.

MEMBER APOSTOLAKIS: This factor of one, formerly one, ECR corrosion --

DR. MEYER: Yes.

MEMBER APOSTOLAKIS: -- was that in the information notice?

DR. MEYER: Yes. In the information notice, we simply said, "Interpret the limit to be the sum of the transient and the corrosion thickness." So, in effect, you're subtracting the corrosion thickness from 17 percent.

And we didn't say multiply it by an F factor. We just said --

MEMBER APOSTOLAKIS: So F is 1.2?

DR. MEYER: F is 1.2 based on our current data and some judgment about the appropriate adjustments to make to account for these cooling rate effects.

Okay. Now what we're suggesting here is that we assume two-sided oxygen pickup everywhere on the run and simply not do a calculation in the balloon. And if you'll let me, I'll show you how I get to that point on the next slide.

And then, finally, we measure the minimum break-away time and use that time as a time limit for the period in the transient above 650 degrees Centigrade. The reasons for all of these choices of numbers --

MEMBER ARMIJO: That time is the same as the time allowable for the entire transient, that you can't get break-away during that transient?

DR. MEYER: The period above 650. Below 650, you're not susceptible to creating this break-away oxide, but above 650, you can get the break-away oxide. And once it starts developing, it may persist, even if you change and move to a different temperature in the transient. So we look for the minimum. And I'll show you some numerical examples.

MEMBER CORRADINI: Just for clarification, Ralph, I just wanted to -- so the ECR is using the Cathcart-Pawel model at 1,200 C.?

DR. MEYER: The ECR unirradiated is the

experimentally observed.

MEMBER CORRADINI: I'm just trying to understand what you just said. So if I were to do a computation, what am I computing? So the ECR unirradiated is using the 1,200 C.?

DR. MEYER: This is a measured result. You do test. And you find the transition from ductile to brittle behavior, just like we showed on those slides. And you do that with Cathcart-Pawel ECR on the *x*-axis, instead of time.

MEMBER CORRADINI: Right. I understand.

DR. MEYER: And you take that number. And that's what you have right here.

MEMBER CORRADINI: Okay. But I am going to say it back to you so I get it right. You don't have a stylized time history for the temperature. So you're using that $ECR_{unirradiated}$ at a constant 1,200 C.?

DR. MEYER: That's correct.

MEMBER CORRADINI: And then the second ECR corrosion is what again? What is that $ECR_{corrosion}$?

MS. UHLE: That's the preexisting corrosion that occurs when the rods are just burned at normal temperatures.

MEMBER CORRADINI: Calculated how?

DR. MEYER: Again, it's measured. The H.

B. Robinson rods had 80 microns of oxide on the surface of them.

MS. UHLE: The licensees --

DR. MEYER: The vendors know what their corrosion rates are so they can tell you approximately.

MEMBER CORRADINI: So this is allowable by the way you're doing this that this is allowable relative to some predetermined corrosion rate buildup as a function of burnup?

DR. MEYER: Correct.

MEMBER APOSTOLAKIS: So for a given burnup, given kind of fuel, the right-hand side of the inequality is a number?

DR. MEYER: Yes.

MEMBER APOSTOLAKIS: On the left, you go to the equation, right?

DR. MEYER: On the left is your --

MEMBER APOSTOLAKIS: Calculation.

DR. MEYER: -- calculation, your --

MEMBER BANERJEE: But you used Cathcart-Pawel first, too.

MEMBER APOSTOLAKIS: Yes. And then the result of that is? Time.

MEMBER CORRADINI: So my last question is to get to the --

MEMBER BANERJEE: It's whatever ECR is the result. It has to be less than the right-hand side.

MEMBER APOSTOLAKIS: Right. But that determines what?

MEMBER BANERJEE: Time and temperature.

MEMBER KRESS: But in making that calculation, you use the area of the clad on both sides?

MEMBER CORRADINI: It doesn't matter. It's the thickness.

DR. MEYER: We're using --

DR. BILLONE: Two-sided oxidation.

DR. MEYER: -- two-sided equations.

MEMBER KRESS: And it's a function of temperature. So you have to do it along the whole wad at different temperatures?

DR. MEYER: Well, you do it just at the peak, like you do now at the peak temperature node.

MEMBER KRESS: You're looking at the peak only?

DR. MEYER: Yes. In this case now, the peak maximum oxidation would always occur at the peak node, peak temperature.

MEMBER KRESS: Okay. So you do it at the

peak. But the temperature is a function of time?

DR. MEYER: Yes.

MEMBER CORRADINI: One last clarification. So Sam asked you about t in the last arrow. So that t always has to be less than the actual transient time because you're going to be much below 650 for a lot of the transient.

I know you don't want to do this, but just to ask it theoretically, so you have gone through all of this effort in the first arrow to take time and wrap it into an ECR. But, yet, you come back to a time measure. So why not just simply have two time measures?

DR. MEYER: Well, that is basically the way I look at it --

MS. UHLE: Well, because we also have to --

DR. MEYER: -- for both of them.

MS. UHLE: We have to subtract off the preexisting corrosion from the ECR calculated. So you need it to be in some sort of format that's consistent.

MEMBER CORRADINI: Okay. But I'm just a crazy academic. So I'll --

DR. BILLONE: No. I understand. I'll

answer your questions.

MEMBER CORRADINI: I know how much the fuel is inside the core. It's in so much time. So I'm got cooking time at one temperature. I've got cooking time during a transient. I have time.

So if you're going through all of the effort to get an ECR and have a stylized thing to be a surrogate for time, then you come back to a second requirement that's time. Why not just simply use time?

DR. MEYER: Well, in most cases, hopefully --

MEMBER CORRADINI: But you know it's the real time of how you have the fuel in the core.

DR. BILLONE: May I try something?

DR. MEYER: The time is the time during the transient.

DR. BILLONE: Time is a simplistic way of presenting this to you. In his first viewgraph he showed you of temperature versus time, you're going to be integrating ECR over that and you --

MEMBER CORRADINI: On the left-hand side?

DR. BILLONE: On the left-hand side. It's not pure time. It's time and temperature, which is a measure of oxidation. And it relates to embrittlement. So if you only go up to 1,000 degrees C., you're going to have the same time period. You're going to get a low ECR calculation.

MEMBER CORRADINI: I'll stop now, but I'm still getting that you have a correction and the correction factor is time of operation time. So I can rearrange the thinking process and take the right-hand side negative, put it over there, and operation --

MS. UHLE: But there's still a temperature issue there because the different rods are at different temperatures. Okay? So we don't know what the -- we can't just say this rod is going to be the limiting rod and we know it's operating temperature throughout the entire life span of that rod.

MEMBER POWERS: It would be a difference between a small break and a large break LOCA.

MS. UHLE: Yes. So you still have a time-temperature type couple there that you need to factor in.

MEMBER CORRADINI: That's a good point. That's true. I understand. Thank you.

So, then, last question about the arrow on the little t. So the history of how any individual rod is sitting inside the core is not going to affect that? That is, I can have a hot rod --

MS. UHLE: That's right. It does not have a burnup effect.

DR. MEYER: So far as we know, that's correct.

MS. UHLE: It's just the time in the transient that exists above the 650 has to be -- and the calculated transient that the licensees provide would have to make sure that the time above that was less than the minimum time.

MEMBER CORRADINI: Thank you.

DR. MEYER: If you let me do one numerical example --

MEMBER ABDEL-KHALIK: Before you take this --

MEMBER ARMIJO: I think we should let Ralph give his thing. I think it's a little bit complicated, but that second criteria is just to prevent really crummy alloys from getting into your reactor. And that's a real simple thing. The real meat of the issue is the ECR during the LOCA transient.

And so there are really two things that they are trying to protect. And I think belaboring that break-away thing isn't worth much, but Ralph should give an example of how he would apply this to a real material.

So I think with that, I am going to have to --

DR. MEYER: Let me show you a good one and a bad one.

MEMBER ARMIJO: Okay.

DR. MEYER: And I'll skip over the five in between.

MEMBER ARMIJO: Okay. Thank you, Ralph.

DR. MEYER: Okay. So here is M5. And if we take a fresh piece of M5 tubing and find the point at which it loses its ductility, it's about 20 percent in this ECR definition. This is a typical value.

At end of life, M5 might have 40 microns of corrosion. And you not make a geometric conversion of 40 microns to the ECR unit. And it happens to be four percent.

MEMBER APOSTOLAKIS: I thought the ECR unirradiated was 17 percent. It's not.

DR. MEYER: It's not. That's part of the problem. One size doesn't fit all.

MEMBER APOSTOLAKIS: Okay. Okay.

MEMBER BANERJEE: It depends on the alloy, I guess.

DR. MEYER: It depends on the alloy. It

probably depends more on a couple of fabrication steps than on the alloy composition. So now if you take 1.2 times 4 and subtract it from 20, you get 15.2 percent. The current limit would be 17 percent minus 4 percent or 13 percent. So, actually, you have a higher limit with this material.

And the measured time at which break-away occurs at the worst temperature is on the order of 5,000 seconds. A typical LOCA is what, 1,800 seconds. So you have no problem with break-away on this material. And you would use in your calculation 15.2, instead of 17. Everything else would run the same way that the current analysis is done.

This is going to ensure you that you have covered the effects of manufacturing variables, alloy, burnup, everything that we have found.

MEMBER BANERJEE: The first number is a measured number --

DR. MEYER: Yes.

MEMBER BANERJEE: -- or a calculated number?

DR. MEYER: Measured. The second one is also measured, but it will come from the vendor's correlation from measurements in the plant.

MEMBER CORRADINI: We know the bad one

already.

DR. MEYER: You know the bad one already is the old style Russian E110, where we measure with the fresh cladding of transition of about 12 percent, not 17 percent.

Now, this cladding is very resistant to corrosion. It has low oxygen content and it's also like the M5 is Zirconium-1 niobium. And so the material, we had some 50-gigawatt day per ton cladding in the Russian program. And that converts to only .5 percent.

So you get a limit of 11.4 percent for this material. If you were using the current rule, it would be 17 percent minus the .5 or 16 and a half.

But look at this. The break-away process starts in about 500 seconds. So after 500 seconds, these limits no longer apply. Very quickly, it will embrittle. And so if you had a LOCA transient with this fuel that spent more than 500 seconds above 650 degrees Centigrade, it probably would not retain ductility after that transient.

Do you want me to quit now?

MEMBER ARMIJO: Yes. We are going to have Dr. Ozer. Dr. Odelli Ozer from EPRI is going to speak for the industry people, although there are some here available to answer questions.

Dr. Ozer?

MEMBER ARMIJO: Do we have handouts of your presentation?

DR. OZER: Ralph?

MEMBER ARMIJO: The blue folder?

DR. OZER: Yes. Thank you very much.

I would like to thank the Committee for giving me the opportunity to express the industry's position on this. I know we are kind of short on time. So I am going to try to be rather concise.

First of all, let me state that we are fully in support of the overall objective of NRC in trying to develop performance-based criteria because such criteria will allow the introduction of new materials without the concern about getting exemptions so the licensing process will be much smoother, will go much faster.

We are also very much in support of the excellent work that is being done at Argonne, the work that Ralph covered in three minutes. You know, we're very much in support of that.

Our concern is primarily with the interpretation of that work and with the proposed changes, the changes that are being proposed to the current criteria.

First of all, I think we all agree that the data has not shown the presence of any public safety issues.

MEMBER POWERS: I guess I just don't understand that statement at all. Do you mean to tell me that it's perfectly okay to embrittle a clad during a transient so that when it shatters during cooling --

DR. OZER: If you let me go --

MEMBER POWERS: No. I want to understand this sentence.

DR. OZER: -- I will address it. I would like to address that to some greater extent. As I said, we do have concerns about the interpretation of the rules and, in particular, the use of the F factor, which has been discussed at length, and the fact that we may be getting oxygen ingress from the ID, how to address that, whether to address it by assuming double-sided oxidation. We are concerned about that as well.

And, you know, the main concern is that we feel that a rather bounding approach will have a rather significant negative impact on the industry. Again --

MEMBER POWERS: I am still coming back to your first sentence. You've got to explain that better to me. It seems to me that it is really a bad idea to embrittle a clad.

DR. OZER: One more slide. We think that the current criteria are conservative. The embrittlement issue was set up some 33 years ago because at that time the concern was that we really didn't know what kind of forces would be exerted on fuel during a LOCA event.

Since then, a lot of experiments have been done, both in Japan and in the U.S., that show that even zero ductility fuel has enough strength to withstand the stresses and strains that result from the quench operation as well as a wide range of impact loads that may be expected following the LOCA. So we feel that there is conservatism in there.

We also feel that there is conservatism in trying to determine when you will lose ductility from ring-compression tests done on de-fueled cladding. We think that those are tests that are very localized; whereas, the response of fuel in the reactor will be more of an integral nature and will be affected by the fuel column that should be present there. So, you know, we feel that those are conservatisms that are present right now.

We also feel that we have margin, considerable margin, today, particularly with regards to high burnup fuel. And this is from a presentation that was made by Westinghouse to the subcommittee a couple of weeks ago which shows the power levels of different fuel as a function of burnup. And we can see that the higher-burnup fuel is way down compared to fresh fuel or even once-burned fuel.

What we have over on the right-hand side is the calculated response of either high-power fuel or the lower-power high burnup fuel, the temperatures that fuel will experience during a LOCA event.

What we can see is that the high burnup fuel is in the 200-degree range. It's nowhere near the limit. And the only way you can get this high burnup fuel to reach the limit of temperatures is by exceeding the limit everywhere else. So, you know, if we're putting a cap on the fresh fuel, we're also de facto putting a cap on the high burnup fuel.

MEMBER ARMIJO: So you are saying that the high burnup effects that are the primary issue related to the 1.2 factor occur only in fuel that cannot reach these temperatures if that's what I heard you say.

DR. OZER: What I am saying is that --

MEMBER ARMIJO: Reach the 1,200, can't

reach 1,100.

DR. OZER: That's right.

MEMBER ARMIJO: There is not enough --

DR. OZER: There is not enough power in the fuel to reach those temperatures. And we are arguing about F factors that will apply for that kind of a fuel.

MEMBER CORRADINI: Why is that? I missed that. I apologize. Why is that?

DR. OZER: Because the higher burnup fuel operates at much lower powers. This is in the reactor, the power distribution in the reactor, fresh fuel, once-burned fuel and second-burned fuel.

MEMBER CORRADINI: So it's strictly a stored energy effect? It's not a decay heat effect? Heat is not going to matter. It's just the opposite then. If it's a decay heat effect, that's irrelevant. If it's a stored energy effect, that's relevant.

I mean, if you're telling me it's power at the moment I have the event I essentially redistribute the stored energy, I accept that, but if it's a decay heat effect, that's not the case.

DR. OZER: Well, again, the decay heat and the power, stored power, produce these lines. This is the response during a LOCA.

VICE CHAIRMAN SIEBER: Near term decay heat is much shorter. Long-term is higher.

MEMBER ARMIJO: But it's all over by that time.

MEMBER APOSTOLAKIS: What are the axes on the first?

DR. OZER: The first one is burnup.

MEMBER APOSTOLAKIS: Burnup?

DR. OZER: Yes.

MR. DUNNE: This is Bert Dunne from Areva. What you are looking at is the peaking factor. And the cladding temperature transient is determined by a normalized decay heat rate times the peaking factor. So your peaking factor carries through into your decay heat as well with time, at least for the time period of a LOCA. So we find that the stuff out here in the third cycle is operating about half of the decay heat that the fresh fuel would be.

MEMBER CORRADINI: So it's mainly stored energy effect?

MR. DUNNE: No. I think it's mainly decay heat and partly stored energy.

VICE CHAIRMAN SIEBER: But those are pretty, on that graph, that shows to me pretty, wide power deviations, which I don't recall power deviations as severe as that.

MEMBER ARMIJO: You mean differences from cycle to cycle?

VICE CHAIRMAN SIEBER: No. Differences from fresh fuel to twice-burned fuel. Well, it runs between about 70 percent and 130 percent, as opposed to I see assemblies there running less than 50 percent.

MEMBER ARMIJO: Yes. They're pretty dead.

VICE CHAIRMAN SIEBER: They're pretty low.

MEMBER ARMIJO: They're pretty dead, but, you know, you get a lot of burnup in one cycle nowadays, so two cycles of burnup.

VICE CHAIRMAN SIEBER: Well, modern fuel designs try to flatten the core as best we can to --

DR. OZER: Well, we tried to reduce leakage as well so that the high burnup assemblies will be on the periphery.

MEMBER ARMIJO: But, you know, I want to make sure that everybody understands that that is what they're saying, that the temperatures achievable as a function of burnup are defined by curves like this. It may be different for BWRs and some kind of PWRs. So the real risk is limited by the achievable temperature during the LOCA.

DR. OZER: Exactly. Thank you.

So, again, we do feel that it is conservative. And now we feel that there are some additional conservatives that are being added on. And that is the use of a single F factor, the requirement of assuming double-sided oxidation, not only in the balloon but everywhere throughout the rod, and, of course, the assumption that the high burnup furl will also oxidize at the limit temperature.

MEMBER POWERS: Let me ask you a question about it. In bright red, you have "Experimental evidence supports the view that embrittled material." That experimental evidence on the forces or is it on the material?

And if it's on the forces, gee, I'd like to know where that information comes from because I have searched in vain for some idea of what kinds of impulses and forces you get during an ECCS recovery.

DR. OZER: This is based on experiments that were done in Japan where fuel was passed through a LOCA heat-up coolant scenario and then quenched. John, would you?

MR. ALVIS: Yes. This is John Alvis from Anatech. The Japanese run their integral samples through a large-break LOCA heat-up. They hold an oxidation period. And then they cool down and quench.

But what the Japanese do with their tests, their requirements are that they hold their tests with axial constraint. So they apply a load to their integral samples during the quench process. And they have discovered that, even with high burnup interval rodlets, that they can reach ECRs out to 20 percent without losing the coolable geometry.

MEMBER ARMIJO: What kind of loads? Are these minuscule? Are they significant loads?

MR. ALVIS: I think they hold their -- what was it? Five newtons?

DR. BILLONE: Five hundred seventy.

PARTICIPANT: The quench assembly.

MR. ALVIS: Right. Their hypothesis is that the grids would lock up or the rods would lock up at the grid spans

MEMBER ARMIJO: So they put these things in bending or some way that would --

DR. BILLONE: Intention, intention.

DR. OZER: What they do is they heat it up. They hold it. You know, they clamp it.

MEMBER ARMIJO: And then they quench.

DR. OZER: And then they quench it. And they see whether it will break or not. And what they see is that even the 17 percent ECR fuel will not break, that you need much higher ECRs to break it.

MEMBER ARMIJO: Based on strength, not on ductility?

DR. OZER: That's correct, yes.

MR. ALVIS: Correct.

DR. OZER: So that's why I'm saying even zero ductility material has enough strength to withstand stresses resulting from quench.

MEMBER ARMIJO: But you are not arguing against a ductility limit, though, right? You accept --

DR. OZER: Not at this point, no. No. But I'm trying to say that there is conservatism in using ductility as a surrogate for what the fuel -- you know, what we are concerned about is coolable geometry. And we're trying to make sure that the fuel will survive a LOCA event.

And ductility was used as a surrogate for anything that may be happening in the reactor during a LOCA event.

MEMBER POWERS: That's exactly what happened, is that nobody knew what kind of forces were going to be placed in the fuel. This seemed to say that you do know. And I'm asking, how do you know that?

DR. OZER: Yes. The only thing that we can say here is that it will withstand the quench, the stresses resulting from quench.

MEMBER POWERS: It's the stresses resulting from quench in a particular experimental apparatus --

DR. OZER: Yes, correct.

MEMBER POWERS: -- with a particular kind of configuration.

DR. OZER: Yes, with a particular load.

MEMBER POWERS: What I'm asking about is now how do I take that and then imply that it's conservative in the reactor? It may be, for all I know, but I just don't know how to do that because I don't know what the forces are.

DR. OZER: Again, I am only using this as an indication that there is some reason to feel that the sky is not falling exactly.

MEMBER POWERS: Well, I mean, when the original rule was developed, people said, "Yes. The ductility criteria will be conservative criteria."

DR. OZER: Yes.

MEMBER POWERS: And they knew it from the get-go.

DR. OZER: Yes. I'm trying to --

MEMBER POWERS: The question we have now is, what do we do about all of these new fuels that are coming along? And how do we keep bad fuels that look compositionally the same as good fuels out of the system?

MEMBER ARMIJO: And how do we account for high burnup effects? I think that's a fundamental issue, how much emphasis is on the high burnup effect, because that's where the F factor is and the 1.2.

And that's where I think the focus of the industry issue is. And we've got to understand that.

DR. OZER: That's right.

MEMBER CORRADINI: May I ask a question at this point? Sam, I think, characterized it. So, really, if I understand your original slide, you have done some calculations. And going from the notice effect, which is in the '98 notice, essentially correcting for it at a factor of one, correcting for it as a factor of 1.2 is going to cause, your point is, undue conservatisms, because already you are correcting for the high burnup using the factor of one if I understood what we were told?

DR. OZER: Yes. Our concern is that a single F factor to account for all of these heat-up, cool-down, quench temperature, material property, material fabrication effects is not going to be defensible in a licensing environment.

MEMBER ARMIJO: So to repeat it differently, you would rather go on a case-by-case basis with separate fuel to the staff?

DR. OZER: No. I think our argument is that, really, we are not ready to, we don't have sufficient data to defend the 1.2.

MS. UHLE: Can I interrupt at this point because I think the conversation is getting a little off base in the sense that we're not talking about rule language. It may be the option that NRR decides that a licensee or a vendor getting a fuel design certified would come up with the F factor. So I think we're getting a little off base.

DR. OZER: Yes. I --

DR. MEYER: Could I also make a comment here. I'm trying to restrain myself, but for these modern alloys, the 1.2 factor has very little effect because, as you saw in the numerical example, the corrosion thickness is low. And the only time that this really is going to have a big effect is when you're dealing with one of the older claddings. There is still some in the plants, like Zircaloy, where the corrosion is high.

DR. OZER: And Ralph gave some nice examples, where we indeed seem to be gaining some margin. So why are we complaining?

MEMBER CORRADINI: That's kind of what I was thinking.

DR. OZER: Right. Well --

MR. DUNNE: This is Bert Dunne from AREVA. One of the things that AREVA wants is for the criteria to be on well-established scientific grounds because we think that is the location at which we can have a long-living criteria. And what I look at is a learning curve to tell me whether or not I am on well-established scientific grounds.

I think we are still learning. Two years ago we had two new effects that we needed to consider. This time we're back up here. We again have two relatively newly discovered or realized effects: the potential for quench temperature cooling rate to have an effect and the ID oxidation.

So we're just kind of saying go slow if you go or we would rather have a period of time when we didn't discover a new effect tomorrow.

DR. OZER: Let me mention the concerns that we have with the F factor. The F factor is trying to cover a lot of territory. It's going to be a function, a very complicated function, of hydrogen content, cladding design actually on time, and temperature history.

We have information that the cooling rate and the temperature at which quench is introduced does have a significant effect on the F factor. Would low quench temperatures, temperatures below 600 degrees, give us a much better F factor, even an F factor less than one?

You know, the impact of these variables cannot be addressed to a single factor. Plus, the F factor is really not appropriate for BWRs because F factor is a multiplier on oxide thickness. And for BWRs, really, the parameter that should be used is the hydrogen content in the cladding.

There is a larger variety or uncertainty about the oxide thickness that would have to be accounted for. And this was penalized at better performing BWR cladding alloys. And this fact was recognized, in fact, by NRR in preparing the proposing interim RIA criteria, which for BWRs are based on hydrogen content, rather than oxide thickness.

There are other problems as well. You know, how do you determine the F factor a priori from prehydrided data? We tried to do an exercise where we took the experiments that were conducted by Argonne on unirradiated matching pairs of experiments, on unirradiated cladding material and hydrided cladding material, and tried to derive an F factor from that. And we see that the F factor is all over the map, going from almost two down to, again, less than one, .7, .8.

What is interesting to note here is that when you go to slower-cooled cases, what we have here is cases that were quenched at 800 degrees because all the quenches, most of the quenches that Argonne has done are done at 800 degrees. And when you either don't cool it or cool it at lower or quench it at lower -- I'm sorry. If you quench it at lower temperatures or slow-cool without quench, you get much better F factors.

We are concerned that the use of 800 degrees for quench temperature is inappropriate or it's overly conservative. Again -- and I'm basing this on this time a calculation or evaluation provided by AREVA for different scenarios. These are two large-break LOCA scenarios. And they estimate the quench to occur below 600 degrees. This one is a small-break LOCA. And the quench here is around 250 degrees.

Now, we have similar results reported from our BWR colleagues that indicate that most of the quench they expect to be occurring around 600 degrees or less. And, again, when you quench at 600, you get a better response. So that's another uncertainty.

MEMBER ARMIJO: Dr. Ozer, before you leave the BWR situation, what is your argument on that? You say the oxidation is not the right parameter to use. Why do you say that?

DR. OZER: Because in a licensing environment, you have to account for all the uncertainties, the uncertainty that you will expect in predicting the oxide thickness. And the BWR people can predict the hydrogen content with less uncertainty than they can predict the oxide thickness. So if it's based on oxide thickness, they would have to take a higher penalty.

MEMBER ARMIJO: Currently aren't they doing that?

DR. OZER: I'm sorry?

MEMBER ARMIJO: Currently they are doing that through the information notice. They're including the oxidation, external oxidation.

DR. OZER: Yes. And now we are applying

a factor on top of that. And we are questioning the adequacy of that factor for BWRs.

DR. MEYER: If you will look at my slide 27, you will see that there wouldn't be any penalty for the BWRs.

MR. JAHINGIR: This is Nayem Jahingir from G&F. Just to clarify Sam's point, we have the ductility loss. And ductility loss is more related to hydrogen than oxidation. And there is some indication that at higher exposure, hydrogen uptake is much higher for like same oxidation for BWR cladding, too. That's why for RIA, we are kind of weighing to the hydrogen space, rather than an oxidation space, because that's actually more related to the ductility.

MEMBER BANERJEE: I just want to ask you a question. If you go back to the previous slide, the pre-cooling phase, before quench, is a fairly rapid cool-down anyway you can see.

DR. OZER: It says here.

MEMBER BANERJEE: Yes. So quench is only a calculation for when the surface rewets. There's extensive heat transfer, which brings the surface down. So why do we put so much emphasis on the quench per se, compared to a process which might be dropping the temperature fairly rapidly?

DR. OZER: The easy answer is that experiments showed that there is an effect. And the effect tends to give better results when the experiments are quenched at 600, as compared to 800.

MEMBER BANERJEE: It doesn't matter how you cool them down?

DR. BILLONE: Yes, it does.

DR. OZER: I'm sure it does.

DR. BILLONE: May I clarify one point? You're talking about CEA experiments. In the Argonne experiments, we found no difference between quenching at 800, 700, and 600 degrees C.

And getting back to the F factor, we can analyze our data and say conservatively we want conservative numbers, 1.6 for the F factor. If you want to take into account that our experimental cooling rates are faster than what you see there and our quench temperatures are higher, then we can justify moving the F factor down.

But 1.2 really applies to quench temperatures below 600 degrees C. and cooling rates 5 degrees C. per second or less on the cooling part before you get to the quench.

MS. UHLE: Again, this is Jennifer Uhle. This is rule language we're talking about --

DR. BILLONE: Right.

MS. UHLE: -- because it may be decided that the licensee is -- it's up to the licensee to determine the appropriate F factor.

MEMBER ARMIJO: Well, the guidance would be in a NUREG somewhere.

MS. UHLE: Right. So the guidance would say that this is the type of test that you need to run and here is the value you need to come up with. But then it could be such that the vendor would then be responsible for coming up with the F factor.

That could be a possible approach if we're talking about -- the concern I think here is that the 1.2 doesn't apply to all different clads.

MEMBER BANERJEE: I guess the question was that the cool-down rate affects this F in terms of whether it's 5 degrees per second, 10 degrees per second, or 15 degrees per second, correct?

MS. UHLE: Well, Argonne has indicated that the temperatures of -- what was it? -- 800, 700, 600 didn't make -- we didn't see that much of a difference.

But, again, if this is something that could be incorporated into the testing program associated with coming up with this F factor, if that's, in fact, the way NRR wants to go, then that's up for debate. And that would be discussed in the stakeholder involvement period.

I think the question is whether or not the phenomena is applicable.

MEMBER ARMIJO: Right. Right. I think you're right. I think how much emphasis you put on ID oxidation due to bonded fuel, you know, how much of an effect that is, the effect of hydrogen and the -- those are the fundamental issues. And you're still arguing how important those things are.

DR. MEYER: This is Ralph Meyer. With regard to the F factor, keep in mind that there is only one set of data in the world. The industry doesn't have another set of data with high burnup fuel rods than those one.

So, you know, you can speculate about how many variables are involved, but it's very tough to go out and measure it for another cladding type when you don't have the data.

MEMBER ARMIJO: But we will have the data in a year or so, won't we, if you get your program going? You know, you get your new hotcell access.

DR. BILLONE: Yes. You will have data for M5. And you will have data for high burnup ZIRLO.

MEMBER ARMIJO: And that's committed R&D? I mean, you've got --

DR. BILLONE: Yes. We don't need new hotcells for that. That's what we're working on right now.

MR. DUNNE: Mike, this is Bert Dunne again. You're talking about the Skuzda examples now?

DR. BILLONE: Right.

MR. DUNNE: What we really want to do is wait for the Oak Ridge program, where we're talking about fuel that -- cladding that has fuel inferior to it so we can learn something about the ID oxygen source and the relative merits of testing irradiated fuel with simulated cladding that's been preloaded with hydrogen.

DR. BILLONE: That's correct. That will be F.Y. 2008 for the fuel tests, but for the cladding tests with the modern alloys --

MR. DUNNE: Still within the time frame that was just mentioned of a couple of years, I hope, if we could stay on schedule.

MEMBER ARMIJO: Okay. Well, Dr. Ozer, are you finished?

DR. OZER: Let me just say a few words about our concern about the oxygen pickup on the ID.

We are not disputing that that may occur. It's just the assumption, again, the recommendation that we assume. We account for it by assuming double-sided oxidation.

We don't -- you know, for this to occur, you have to have strong, either very strong, contact or bonding. And we think that the results, the experimental results, are inconclusive. This can only be or can best be demonstrated from integral tests.

So far there have been no integral tests on PWR fuel. The only integral tests we have are on BWR fuel. And those are -- you know, I'm taking this graph from the draft NUREG. And this is cladding that has been irradiated. The burnup of the fuel rod was 52. We estimate that at this elevation, the burnup here is 57, where bonding should have been rather significant.

We see a clear alpha layer on the outside. On the inside, there are some regions where it is said there is no alpha and other regions where it is said there is alpha.

I think one has to be really quite a metallurgy expert to differentiate any kind of an alpha layer here, much less differences between A and B.

So we feel that this is a question that has to be resolved with additional experiments. And there have been some statements made that additional experiments, integral experiments, will not be available for years.

MEMBER ARMIJO: But you know that in high burnup BWR fuel, there is fuel clad bonding.

DR. OZER: That's right.

MEMBER ARMIJO: You've seen it. It's not 100 percent uniform. And it's a function of burnup and some clad designs. Is it the same in PWR fuel? It has higher external pressure, maybe tighter contact. I don't know.

DR. OZER: We don't know.

MEMBER ARMIJO: I think that can be explained by doing integral experiments. Argonne has --

MEMBER POWERS: Can we do this with -- I mean, isn't this just a matter of looking at irradiated fuel? I mean, I'm trying to think about how you would do it experimentally. I don't think you can do a persuasive experiment here.

DR. OZER: You would have to run it through a local scenario, the heat-up scenario, to see how.

MEMBER POWERS: I thought that --

DR. OZER: Again, we're not disputing the fact that it occurs. It's just how to account for it and how important is it. And also we are concerned that if we assume double-sided oxidation, this may be interpreted, assuming you're calculated double-sided oxidation. And we may have to take, may be required to take, into consideration the energy of oxidation, which at high temperatures could be quite significant and would result in a penalty in the --

DR. BILLONE: No, no. That was never proposed. You're not forming any oxide in this event on the idea of the --

DR. OZER: I think you have to be clear about that because --

DR. BILLONE: No. We were very clear about what you use for the --

MEMBER POWERS: You're heat of dissolution is going to be so close to the heat of oxidation that I don't think you have gained anything here.

DR. BILLONE: Very clever, actually. You know that. Very clever.

MEMBER POWERS: I mean, it's hard to imagine how you would keep up here on the inner surface uniformly. I think you get mass transport limited on the oxidation.

DR. OZER: As far as experimental data is concerned, I would like to say that we don't think that Argonne is an island of information in itself. I think Argonne has worked closely with other laboratories and has benefitted a lot from interactions with other labs in trying to resolve discrepancies. And I think work at these other labs is ongoing.

And I think probably the most relevant work is being done at the Halden Lab, where, indeed, high burnup fuel rods are being subjected to LOCA-like scenarios in reactors.

So, you know, these questions about heat-up, heating up from the inside, as opposed to heating up from the outside, you know, the Halden results will not be as sensitive a results being done in laboratories like ANL.

These results are expected later this year.

MEMBER ARMIJO: That is part of the NRC confirmatory research?

DR. OZER: NRC participates in the Halden program. I mean, they send representatives. And so do we. But, you know, it's a Halden program.

DR. MEYER: Yes. We're in the Halden project. They're not doing any embrittlement measurements. They're looking at ballooning and axial fuel relocation.

DR. OZER: And they should be able to provide us with metallurgy information about away from the balloon, extent of oxidation.

MEMBER ARMIJO: But they will take it to rupture.

DR. OZER: Yes.

MEMBER ARMIJO: And so if there was oxidation from the ID when they do their metallography, they should confirm or correct --

DR. MEYER: Yes, this is true.

DR. OZER: I don't know whether I should go into this. I think we're out of time, but --

MEMBER ARMIJO: I think we got your message.

DR. OZER: -- with respect to that it's going to be quite costly for the industry to implement this, in conclusion, again, we don't feel that there is a public safety, urgent public safety, issue at this point. And we feel that the bonding approach that is being proposed is premature.

MEMBER ARMIJO: Well, you know I have a

dilemma. And I'm just going to make my little speech. And that's to both parties: industry and the staff.

I hear that there is no urgency. And I hear that there is urgency. I hear that there is going to be a big impact to the industry. Yet, Ralph's calculations show there is no impact. But if there is no impact, why is there urgency?

So I can't get around all of these claims.

MS. UHLE: The urgency primarily stems from what is required in the regulation and what is voluntarily done by the licensees. For instance, the break-away oxidation metric, that is not in the regulation.

If a new cladding were to be submitted for approval, there is nothing in the regs that would require any concern about the break-away oxidation. Yet, you can see with the fabrication process of the E110 that that was a strong effect. Okay. So --

MEMBER ARMIJO: Right now you have no guidance or no regulations that require the --

MS. UHLE: Break-away.

MEMBER ARMIJO: -- suppliers to even think about break-away.

MS. UHLE: That's right.

MEMBER ARMIJO: Okay. So that's a

deficiency.

MS. UHLE: And so when we say there is no urgency, that is because we have talked to NRR about this. And NRR has gone out voluntarily and done a spot check to see "Okay. Is there a safety issue looking at how the licensees are currently operating, voluntarily operating that way?" That doesn't preclude them from changing the way they operate.

So with that, we can say --

MEMBER ARMIJO: They're not likely to do that.

MS. UHLE: Well, again, that would come in from introduction of a new clad design. That could be a change in the way they operate within the regs as written. And they are free to do so. They don't have to tell us exactly what they're doing on a day-to-day basis.

DR. OZER: But couldn't that be addressed through a reg guide?

MS. UHLE: There is no regulatory requirement that would force anybody to take this into consideration.

MEMBER ARMIJO: Unless there are some other questions, I think I am probably way out of time, Mr. Chairman. And I would like to end this part of the session.

Okay. Thanks, everybody. I think we got the issues on the table. Okay. Dr. Shack, it's all yours.

CHAIRMAN SHACK: Yes. It's time for a break. We would like to make it a short break since we are a little bit behind. If we could come back in ten minutes?

(Whereupon, the foregoing matter went off the record at 10:29 a.m. and went back on the record at 10:43 a.m.)

CHAIRMAN SHACK: I would like to come back into session, everybody. Yesterday I read the qualifications and experience of our new senior staff engineer, Ms. Zena Abdually. And she will be helpful in the Committee's review of power uprate applications, thermal hydraulic issues, and TWR sump performance issues.

What I neglected to do yesterday was to welcome her aboard. And I would like to do that today.

MS. ABDUALLY: Thank you.

(Applause.)

8) DRAFT FINAL REVISION 1 TO REG GUIDE 1.189 (DG-1170), "FIRE PROTECTION FOR NUCLEAR POWER

PLANTS," AND SRP SECTION

9.5.1,"FIRE PROTECTION PROGRAM"

CHAIRMAN SHACK: Next up on our agenda is a presentation on reg guide for fire protection and the SRP 9.5.1. And we'll be lead through that by Jack Sieber, our Fire Protection Subcommittee Chairman.

VICE CHAIRMAN SIEBER: Thank you very much, Mr. Chairman.

8.1) REMARKS BY THE SUBCOMMITTEE CHAIRMAN

VICE CHAIRMAN SIEBER: this is a major effort by the staff, the revision of reg guide 1.189, which was draft guide 1170 in its earlier days. It is sort of a companion to the 805 risk-informed fire protection effort.

And the purpose of reissuing this, among others, is to consolidate all the references, of which there are over 100, to preexisting documents and consolidate those into a document that is easier to read and easier to follow. The latest document does not introduce or break new ground in the fire protection area, but it is more a consolidation.

We mentioned SRP section 9.5.1. That has now been incorporated into the draft reg guide, which we're reviewing. And so because of that consolidation, we need not conduct a review of a separate document.

What I would like to do now is introduce Cornelius Holden, who is responsible for the overall effort in this guide, to introduce to us the staff personnel who worked on this and are responsible for it.

MR. HOLDEN: Thank you very much.

8.2) BRIEFING BY AND DISCUSSIONS WITH REPRESENTATIVES OF THE NRC STAFF

MR. HOLDEN: I am Cornelius Holden, Division Director, Risk Assessment. With me today is Sunil Weerakkody, who is our Branch Chief for Fire Protection; and Bob Radlinski, who is our senior person on this effort, will be conducting the briefing today. With that, Bob?

MR. RADLINSKI: Good morning. everybody.

Dr. Sieber, you covered my introduction pretty well.

VICE CHAIRMAN SIEBER: Okay.

MR. RADLINSKI: So move on to the next slide.

VICE CHAIRMAN SIEBER: Yes. Just so the Committee recognizes it, a couple of months ago, we wrote a letter on this draft guide for public comment, suggesting that the staff issue it. And now the comments are back and we're revisiting the subject again.

MEMBER APOSTOLAKIS: So our letter just said to issue it?

VICE CHAIRMAN SIEBER: Issue it for public comment.

MEMBER APOSTOLAKIS: Comment on --

VICE CHAIRMAN SIEBER: Well, there were a lot of comments that came back. We did not have any comments.

MEMBER APOSTOLAKIS: So we are allowed to make comments today?

VICE CHAIRMAN SIEBER: You could have made them even better two months ago.

(Laughter.)

VICE CHAIRMAN SIEBER: Okay.

MR. RADLINSKI: Okay. The objective, as we have mentioned, is that we are going to describe how the NRC staff addressed the public comments that were received on the reg guide and also, of course, to obtain ACRS permission to issue the reg guide.

Just to summarize the comments and the responses, the NRC received 95 what are called new comments on the draft guide. All of those comments were from NEI. The reason I say "new comments" is because they also included 16 additional selected comments that were made on the previous draft guide of the original version of draft reg guide 1.189 when it was issued the first time.

There were excellent comments, very constructive. We incorporated or agreed with 67 of the 95 comments. It's over 70 percent. And the final draft will reflect those comments.

Also, earlier this week we had a public meeting to summarize what our resolution was of those comments, an opportunity for additional discussion. And that went very well.

Also, in the interest of time, my presentation today is only going to talk about the comments that we did not agree with and/or significant issues.

MEMBER APOSTOLAKIS: Can you give us some idea of what kinds of comments you agreed with? I mean, were they editorial or substantive or --

MR. RADLINSKI: Combination, nothing that would change positions or anything. It just added clarifications. They were very helpful in identifying areas where we may have assumed or we had thought that the regulatory requirements were clear. But obviously because of the comment, they were not. So we added some additional clarification.

Okay. There were basically seven categories of comments that we did not agree with. The first was that some of the guidance in the revised reg guide is a backfit.

Now, the second is that we should not issue the reg guide at this time because of the comments that the Commission had with respect to the generic letter that we recently submitted for publication on spurious actuations.

The third is that we should endorse industry standards in lieu of issuing the reg guide.

Next is that the guidance that is provided in generic letter 81-12 should be applicable to III.G.2 areas, the appendix R III.G.2, as well as III.G.3 areas. Of course, I'll be getting into more detail in each of these issues.

The next one is that detection and suppression are not necessarily required with operator manual actions when they are accredited for a III.G.2 area.

MEMBER APOSTOLAKIS: What does that mean, by the way?

MR. RADLINSKI: There has been quite a bit of discussion about this. With all of the actions and discussions that have gone on over accrediting of operator manual actions for III.G.2 areas, we issued a RIS, 2006-10, that talked about this.

The industry contends that if they are able to credit an operator manual action in lieu of the protection requirements of III.G.2, then detection/suppression, which is generally required by III.G.2 or portions of III.G.2 and III.G.3, are not necessarily part of that design. They would not necessarily be required.

VICE CHAIRMAN SIEBER: It has been the staff's position that they are required.

MR. RADLINSKI: Yes. We have been steadfast in that position. Let's see. Item 6, some of the new reactor guidance that we have added to the reg guide.

Actually, the reg guide did not have any new reactor guidance in it before. A lot of it was -- there had been some in the previous version of the SRP. And we rolled that over into the reg guide and also added some new guidance. The comment is that some of that new guidance is not a specific requirement of the regulation.

And, finally, I think we mentioned this in our last meeting before we sent the reg guide out, that we would like to revert to 50.59 as a basis for evaluating plant changes for fire protection.

Okay. The details. On the backfit, again, the gist of the comment was that some of the new and revised guidance in the draft guide would be a backfit for existing plants.

We went back to the process with the original issuance of reg guide 1.189. We looked at the CRGR meeting minutes. And the full Committee reviewed that document. And they reach a conclusion that it was not a backfit, that a backfit analysis was not required. That was essentially based on the fact that compliance with the reg guide is not required, it's not imposed compliance, and that compliance should be assessed against a plant-specific licensing basis, not against the reg guide. And licensees performing their own self-assessments should also do those assessments against their licensing basis and not the reg guide.

Although we added some guidance and changed some of the existing guidance in the original version, the same basis for a no-backfit conclusion would also apply to the current revisions of the reg guide.

And, in addition to that, we did review

the latest version with the CRGR chairman. It was agreed that the update is likewise not a backfit and does not require a backfit analysis.

MEMBER MAYNARD: Just from a practical standpoint, I understand your bullets, your points there relative to the backfit. But that would almost be saying that the reg guide basically is not going to be used in any assessment or evaluation or anything.

It's saying that compliance is going to be based against the licensing basis, not the reg guide. So what's the purpose of the reg guide if it's not going to be used in any assessment?

MR. RADLINSKI: Okay. Of course, any reg guide is one acceptable approach to regulations. To my mind, it will be used as a baseline for a licensee who has a configuration that isn't addressed in his plant licensing basis, isn't addressed even in the regulations.

This would be the baseline for an inspector to say, "Okay. This is one approach that will work. This is one approach that would be acceptable to the staff for meeting the regulations in general. If you are not doing it this way, then you can propose something else and explain to us why that's acceptable and why it meets the regulations."

So this is kind of a starting point. It gives the inspectors, gives the licensees a baseline for what would be considered by the staff to be an acceptable approach. So that's kind of how it will be used.

MEMBER MAYNARD: So if they propose an alternative approach, you would be assessing that against the licensing basis, not starting with the reg guide 1.189 as a minimum level of effort?

VICE CHAIRMAN SIEBER: Correct.

MR. RADLINSKI: Correct.

VICE CHAIRMAN SIEBER: In fact, the starting point, reg guides are issued to licensees as well as internal use by the agency. And my experience in licensing is that's where you go first because it's the easiest amount of work.

If you do the things in the reg guide, then you don't have to come up with an alternative solution. If you can't do them because of configuration in your plant or you have a better idea, that becomes an exception which you identified to an inspector when he comes to inspect you for compliance.

MEMBER MAYNARD: But it's also been my experience that these tend to become more or less minimum acceptable requirements. You may propose alternatives, but a reg guide does set kind of a threshold level there. I understand your point.

MR. RADLINSKI: It still can't be waived by the inspector saying, "You're not complying with this." Okay? It's not a basis for compliance.

VICE CHAIRMAN SIEBER: There is a statement right in the preamble to the reg guide that explains what its legal purpose is.

CHAIRMAN SHACK: You all sort of know the legal purpose.

VICE CHAIRMAN SIEBER: Yes. Well, I mean, if you want to interpret it in your own way, that's up to you, but I read what is written down.

MEMBER MAYNARD: There's also a practical side of how this actually gets implemented. So I think we need to move on.

VICE CHAIRMAN SIEBER: Right.

MR. RADLINSKI: Okay. Another favorite topic: multiple spurious actuations. You are probably all familiar with the generic letter that was prepared on this issue, particularly with the respect to the approach of one at a time is an assumption that would provide a basis for post-fire safe shutdown circuit analyses.

The comment was that you shouldn't be

issuing this reg guide because of Commission comments on that generic letter. Our response is that we did revise the wording in the draft guide, which was from the public comment version, that we did basically water down the language.

We are now no providing any specific guidance on what approach to use for circuit analyses with respect to one at a time. However, we do include a note and continue to include that that based on the industry cable fire tests, a one-at-a-time assumption for spurious actuations may not adequately address the potential risks due to fire, so just kind of a flag to licensees that there may be a problem if you use that assumption as a basis for your circuit analysis.

We also note or the Commission comments on the generic letter based on our changes that we made to the design guide that really don't warrant not issuing the reg guide. It's one issue. And we have kind of watered it down or softened it quite a bit.

VICE CHAIRMAN SIEBER: So the generic letter now still rests as a draft and the issue is still out there. If the Commission changes its mind about the staff's approach to the generic letter, would that warrant the change to this reg guide?

MR. RADLINSKI: A future revision to the

reg guide probably will incorporate the guidance that we plan to put into the ultimate generic letter that is issued.

One of the main comments the Commission had was that we basically said, "Hey, industry, you have a problem," but we didn't tell them how to fix it.

VICE CHAIRMAN SIEBER: Okay.

MR. RADLINSKI: And they want us to work with the industry to come up with the methodology and the acceptance criteria to address the potential problem.

VICE CHAIRMAN SIEBER: So we should stay tuned?

MR. RADLINSKI: Yes, yes.

VICE CHAIRMAN SIEBER: Okay. Thank you.

MR. RADLINSKI: Any more questions on that?

(No response.)

MR. RADLINSKI: Okay. One of the comments referred to some public law that basically said that the government agencies should use industry consensus standards if they were available as a replacement for things like reg guides.

They specifically mentioned NFPA 804. For those of you not familiar with 804, it is strictly for new reactors. And it is a deterministic approach to fire protection. Okay?

There's another version, 806, that's coming out that's for new reactors, which is a risk-informed, performance-based approach. And I might note that AP-1000, also the SBWR have referred to 804.

Now, 804, like any other NFPA standard, is, you know, an appropriate standard to be referred to and provide guidance for the design of the fire protection program, however porous. It must be done in accordance with the regulations.

Also, 804 was just reissued, revised and reissued, in 2006. I think the first version was 2001, but that was a previous version. And there were a lot of changes. And we're reviewing it, but we haven't completed our review yet.

And by issuing reg guide 1.189 now that does not preclude a possible future endorsement of 804, you're --

CHAIRMAN SHACK: I was sort of left with the question of what would a new plant use for guidance.

MR. RADLINSKI: For performance-based?

CHAIRMAN SHACK: Well, performance-based and even deterministic.

MR. RADLINSKI: Well, deterministic, as I say, they haven't --

CHAIRMAN SHACK: This is complete enough?

VICE CHAIRMAN SIEBER: Yes.

MR. RADLINSKI: When you say, "this," the reg guide?

CHAIRMAN SHACK: The reg guide, yes.

MR. RADLINSKI: The reg guide is fine. And, like I say, they are also referring to 804, just like they would refer to NFP 13 for sprinkler systems and 15 for water spray, it provides some additional guidance.

But I would also like to point out that there are some things in 804 that we don't agree with that we don't consider them to be meeting the regulatory requirements.

The comments in this regard also mentioned NEI-0001, which is the industry guidance for performing post-RSA shutdown analyses. That's not really a consensus standard.

And also we have already not endorsed necessarily, but we have provided statements of staff acceptance of NEI-001 in a RIS and also in reg guide

1.205 for the --

CHAIRMAN SHACK: On the performance base, they still have the problem, right, because that guidance is not out yet for new reactors?

MR. RADLINSKI: For new, yes, that's a good point. There is an 806 coming out, NFPA 806. That will be the industry consensus standard for new reactors using a performance-based environment.

CHAIRMAN SHACK: Now, will you have a very high priority on reviewing that when you --

MR. RADLINSKI: We are. We have already submitted two sets of comments. We reviewed it in great detail, submitted a lot of comments the first time around. Most of those were incorporated. Maybe 80 percent were incorporated. It's back now again for the final review by the staff.

MEMBER APOSTOLAKIS: When will we see this? Is the ACRS going to see that, 806?

MR. RADLINSKI: Sunil, I don't know if you have --

MR. WEERAKKODY: Yes. This is Sunil Weerakkody. We have no plans to bring 806 to SRS on this unless you request. It's still in the works.

MEMBER APOSTOLAKIS: It's still what?

MR. WEERAKKODY: It's still being

delivered by the Code Committee.

MEMBER APOSTOLAKIS: I understand. But at some point, you will have to issue a regulatory guide, whether you agree or not, and accept 806 with exemptions and so on. And we get involved at that stage?

MR. WEERAKKODY: We don't plan to because we believe what's in the updated reg guide that you see today, which incorporates the high-level guidance on new reactors is sufficient.

Now, in our review process, what we are trying to do is make sure that 806 or 805 is in that plan. So we have no initiative to endorse 804 or 806 at --

CHAIRMAN SHACK: From performance-based?

MR. WEERAKKODY: Right now we don't have a plan to go in and endorse 806 for new reactors.

CHAIRMAN SHACK: So you're saying you don't plan to have guidance for a performance-based approach for new reactors?

MR. WEERAKKODY: At this point we don't think that's necessary. That's correct. I think if you look at the advanced rectors, if you look at the advanced rectors, what we have really done is risk-informed the design itself. Okay? You don't need a deterministic indicator. You basically have every area fully supported.

MEMBER APOSTOLAKIS: We'll come to the advanced reactors on slide 11. And I had some problems with the appendix. Is it an appendix? Whatever it is. Yes, I think it's an appendix. But I'm a bit surprised. I mean, this is, yes, appendix B.

Don't we typically, I mean, following this public law, look at these industry standards and then express a view as to how much of those standards is applicable? You will do that sometime in the --

MR. WEERAKKODY: Yes, if there should be a need. That's what I'm saying, Dr. Shack, saying. Now, if there is a need, if somebody said, any stakeholder said, "Look, why don't you consider endorsing 806 in the rule," we definitely would look at it at that state. Okay?

But if nobody wants it, why would we want to spend the time? But in the meantime, though, like Bob said, we are very closely wording the review. But I have two people in my staff in that code committee.

MEMBER APOSTOLAKIS: It is just a matter of timing and need.

MR. WEERAKKODY: Yes, sir.

MR. RADLINSKI: We will look at it in the future, but it's just not time yet. I mean, they haven't even issued 806 yet.

MEMBER APOSTOLAKIS: I understand.

VICE CHAIRMAN SIEBER: The reason for issuing this reg guide as a draft at this time is because of the potential for new reactors. And this goes along with a whole suite that the staff has been working on the last few months.

MR. RADLINSKI: And the new reactors will have fire PRAs.

VICE CHAIRMAN SIEBER: Right.

MEMBER APOSTOLAKIS: Well, I don't know about that, but I am waiting until your slide 11.

MR. RADLINSKI: All right.

MEMBER APOSTOLAKIS: See how well I control myself, Bob.

VICE CHAIRMAN SIEBER: Moving right along.

MEMBER APOSTOLAKIS: Discipline.

MR. RADLINSKI: Okay. We are on slide 8 now, generic letter 81-12 and appendix RIII.G.2. The comment was that the guidance in generic letter 81-12, which has a very general title of "Fire Protection Rule," should apply to appendix R, section III.G.2 areas as well as III.G.3 areas.

Our response to this is that this was covered extensively in a RIS that we published in 2005. It's RIS 2005-30. It addresses the issue. That RIS was issued for public comment because of the controversial nature of it.

We received public comments, numerous public comments. We even had a follow-up public meeting to address each and every one of those comments. That RIS was also reviewed by CRGR for backfit. And it was issued final in December, on December 20th in 2005.

And essentially what it says is that generic letter 81-12, the guidance provided by the generic letter. And there was a follow-up memorandum that provided additional guidance.

All of that is clearly applicable to alternative dedicated shutdown capability and not to III.G.2. I mean, it's related to the III.G.2 indirectly in the sense that some of these associated circuits of concern could cause damage or prevent a redundant train from shutting down the plant.

But other than that, I think the industry -- they haven't said it specifically, but I think they're focused on the fact that one of the mitigating components or one of the options for mitigation of a spurious actuation of an associated circuit of concern is an operator manual action. And they would like to apply that to III.G.2. Of course, that's not the case.

Okay. Operator manual actions and detection/suppression. As I mentioned before, the comment is that we have inappropriately implied that if you credit an operator manual action in the III.G.2 area, then you don't necessarily have to provide detection and suppression. That may be true, but as a baseline, it should be assumed that that is fundamental to the fire protection that you're providing in that area.

As we all know, there are three components to fire protection defense-in-depth. You prevent the fire. If you do have a fire, then you detect it. And you suppress it. And then, finally, you assure safe shutdown in the event of that fire.

Operator manual actions typically support the third component. They serve as a substitute for the electrical raceway fire barrier system or separation. They do not eliminate the need for the other components. Okay?

MEMBER APOSTOLAKIS: They also support it, though, don't they?

MR. RADLINSKI: They support?

MEMBER APOSTOLAKIS: The operators detect the fire and alert the fire brigade.

MR. RADLINSKI: Right.

MEMBER APOSTOLAKIS: Is it just the sub-bullet? When we say, "Operator manual actions," I guess we mean a specific set of manual actions."

MR. RADLINSKI: Well, we're talking about a situation where you have a III.G.2 area. We have redundant trains in the same fire area. And you have removed your electrical raceway fire barrier system, thermal lag, or whatever and you have replaced it with an operator manual action to mitigate the failure of that circuit that's no longer protected.

MEMBER APOSTOLAKIS: So it's that specific set of manual actions that OMA refers to?

MR. RADLINSKI: Right. And the industry --

MEMBER APOSTOLAKIS: The industry --

MR. RADLINSKI: Okay. If I do that, if I take that approach, then I don't have to have detection suppression in the area of consideration.

MEMBER MAYNARD: If you have detection and suppression, why do you have to rely on operator actions?

MR. RADLINSKI: Defense-in-depth.

VICE CHAIRMAN SIEBER: Detection and suppression are not a substitute for the fire barrier.

MEMBER APOSTOLAKIS: It's for the fire barrier.

VICE CHAIRMAN SIEBER: There's a separation requirement, which can be achieved by barriers or distance.

MEMBER APOSTOLAKIS: Because I guess some of the plants could not meet the appendix R separation criteria or is that the idea?

MR. RADLINSKI: In a number of cases, it was because of the thermal lag issue, where they just took the thermal lag off or just didn't credit it any longer and said, "Okay. We'll assume that that cable tray is going to burn up." Okay? Since that cable trap is going to burn up, I'm going to have to take some operator manual action to mitigate the --

VICE CHAIRMAN SIEBER: Spurious operations.

MR. RADLINSKI: -- spurious actuations that could prevent safe shutdown.

MEMBER BANERJEE: But the new plants will be able to meet the separational requirements.

MEMBER APOSTOLAKIS: They should.

MR. RADLINSKI: Yes. That's part of the enhanced fire protection. We'll talk about that later. But they won't be able to do that 100 percent on the cases. It's not --

MEMBER BANERJEE: Well, why not?

MR. RADLINSKI: It's just not physically possible. I mean, you just have areas of the plant where things come together.

VICE CHAIRMAN SIEBER: Like the control room cable spreading.

MR. RADLINSKI: Right, obviously the control room but under the reactor vessel and areas like that.

VICE CHAIRMAN SIEBER: You have two reactors.

MEMBER APOSTOLAKIS: With different manufacturers for the --

VICE CHAIRMAN SIEBER: A reactor and B reactor.

MEMBER APOSTOLAKIS: -- diverse vessels.

VICE CHAIRMAN SIEBER: Moving on.

MEMBER APOSTOLAKIS: Dr. Kress will tell us that the --

VICE CHAIRMAN SIEBER: You have to add them, right. Moving on.

MR. RADLINSKI: Okay. The main control room complex fire protection. The comment was that "The following should be deleted from the guidance that's in the reg guide."

One is to provide suppression for peripheral rooms that are adjacent to the main control room. The other is that the industry does not believe that smoke detection in the individual cabinets within the main control room is necessary.

First of all, the auto suppression in the peripheral rooms may be required by appendix R, section III.G.3. Okay? Obviously the control room is a III.G.3 area. You have alternative shutdown and in the --

VICE CHAIRMAN SIEBER: It depends on the strength of the barrier.

MR. RADLINSKI: Right.

VICE CHAIRMAN SIEBER: That's a natural place for a fire, computer rooms, offices.

MR. RADLINSKI: Right, offices with paper.

MEMBER BANERJEE: Are these suppression systems primarily sort of rapid system?

MR. RADLINSKI: No, no. Water.

MEMBER BANERJEE: Water sprays?

MR. RADLINSKI: Just like an office. And

with respect to cabinet detectors, they made the argument that control rooms continually man. The operators are there. But products of combustion detectors, inside cabinets may detect the fire more quickly than an operator's eyes or nose since they're detecting visible products of combustion.

But, more importantly, the detectors in the cabinets tell you exactly where that fire is. Okay? If you're an operator and you smell smoke or the ceiling detectors set off the alarm, you may not know where that fire is. You may have to go around opening cabinet doors to try to find it.

MEMBER ARMIJO: What's the logic for saying, "Don't do that"? I mean, why would they say --

VICE CHAIRMAN SIEBER: It costs money.

MR. RADLINSKI: It costs money and --

MEMBER ARMIJO: It can't cost that much.

MR. RADLINSKI: To be honest, the NRC has allowed them to not do that in a number of cases. They've submitted exemption requests. And we have approved them.

MEMBER ARMIJO: It can't cost that much.

VICE CHAIRMAN SIEBER: Everything costs a lot.

MR. RADLINSKI: But, interestingly enough, and the 804 actually required cabinet detection. And that's the industry standard that they would like to adopt.

MEMBER APOSTOLAKIS: Is that the standard that we have approved, the agency has approved?

MR. RADLINSKI: No.

VICE CHAIRMAN SIEBER: No.

MEMBER APOSTOLAKIS: No?

MR. RADLINSKI: Okay. Now we're on --

VICE CHAIRMAN SIEBER: Is there an error on page 10? Is there an error? On page 10, is there an error on that slide?

MR. RADLINSKI: Oh, yes. On the handout? Did I mention that? For some reason, the handout didn't get the correction. It's correct in mine. It should be III.G.3, not III.G.2.

VICE CHAIRMAN SIEBER: Okay. So for the members who would make that --

MR. RADLINSKI: Thank you for bringing that to my attention.

All right. The comment with respect to new reactors, one of the comments, was that the guidance that we've added is not specifically required by the regulations. And specifically we made comments to the effect that new reactors should have minimal reliance on operator manual actions and alternative shutdown and also that operator manual actions should be avoided.

Furthermore, we said that reliance on electrical raceway fire barrier systems should be minimized. They objected to the use of these terms. And the comment was that those terms and that guidance is not in the regulations anywhere.

This is guidance. The reg guide provides guidance. And these are considered to be appropriate goals for new plants, where the fire protection protection program can be integrated into the planning and design phase of the plant.

Furthermore, it supports the Commission's concept of enhanced fire protection for new reactors, although, again, it's not in the words or the description of the enhanced fire protection. But it's also consistent with GD-C3.

MEMBER APOSTOLAKIS: Yes. The issue of new reactors in fire protection, all the risk-informed initiatives we have undertaken the last eight, nine years have been voluntary.

And the argument has been, you know, we have already licensed the existing reactors using separate criteria. So we can't really go back and impose now that they become risk-informed. So they're voluntary.

And that has led to situations where we are really dancing around an issue. If you do this, you do that. If you do this, you do that. But for new reactors, why don't we demand that they be risk-informed? In other words, it seems to me that there is a general consensus that NFPA 805 is a good thing to have. And we like plants to follow NFPA 805, assess the risk.

And then if they want to change later, you know, they can do a risk evaluation and go to the regulatory guide and so on and so on because it gives an integrated view of the plant.

Why can't we say that new reactors should follow the NFPA 805?

MR. RADLINSKI: I wish Ray Galucci were here to hear you say that. I'm sure he would appreciate it.

MEMBER APOSTOLAKIS: Is there anything in the regulations that forbids that?

VICE CHAIRMAN SIEBER: I think you have to do it by rulemaking --

MR. RADLINSKI: Right.

VICE CHAIRMAN SIEBER: -- if you want to impose it as an absolute requirement.

MR. RADLINSKI: Okay. That's a legalistic argument, I mean. Then you go to appendix B, which refers to fire probablistic risk assessments. And you see things like a detailed fire PRA is not necessarily required for a new reactor fire protection program.

And then later on it says, however, if an applicant for a combined operating licenses references a certified design and if that certified design developed a fire PRA, then we impose additional requirements that the PRA has to be reviewed, right, and all that stuff, which I don't see here right now.

But, I mean, we put all these "ifs." And we rely on the good will of the applicant to do the PRA. So if somebody doesn't do a fire PRA, then they don't have to do all these things and they go back to being deterministic and all of that.

In other words, we are perpetuating this situation of having two parallel regulatory systems, I mean. And at the same time, we see major utilities right now switching to NFPA 805 because they believe it's to their advantage.

MR. RADLINSKI: Right.

MEMBER APOSTOLAKIS: Why have all of these ifs that a detailed fire PRA is not necessarily required but if their certified design developed a fire PRA --

VICE CHAIRMAN SIEBER: Where are you reading from, George?

MEMBER APOSTOLAKIS: Appendix B of this.

MR. RADLINSKI: I believe the "ifs" are there because we don't have the regulatory rule in place for that. But it's very important to note that AP1000 and ESBWR, both DCDs, both have fire PRAs, --

MEMBER APOSTOLAKIS: Yes, but where --

MR. RADLINSKI: -- which means that the COL applicants must adopt that fire PRA and maintain it.

MEMBER APOSTOLAKIS: Yes. It says, "Then the COL applicant is to use that PRA and update it to reflect site and plant-specific information that may not have been available at the design stage. In addition, the licensee that has a risk-informed performance-based FPP similar to NFPA 805 or that plans to evaluate plant changes using a risk-informed approach must have a detailed fire PRA."

And you look at all of this and say, "Well, gee, they're asking me to do all of these things if there is a fire PRA in the certified design.

And if there isn't, then what do I do? I go back to appendix R?"

MR. RADLINSKI: The reality of the situation is that you are going to get what you want. They do have fire PRAs.

MEMBER APOSTOLAKIS: But how do you know that in the future they will also have fire PRAs?

MEMBER BANERJEE: Well, it will be EPR, right?

MEMBER APOSTOLAKIS: Does EPR have a fire PRA?

MEMBER BANERJEE: Well, it hasn't come yet, but I presumed it would.

MEMBER APOSTOLAKIS: Is that a good way to regulate?

MEMBER BANERJEE: Well, you can not reference the design if you don't want to reference.

MEMBER APOSTOLAKIS: It seems to me, though, that the NFPA 805 appears to be the way to go.

MR. RADLINSKI: But it's not for new reactors. It's specifically for --

MEMBER APOSTOLAKIS: No. It's doesn't say anything, right? I mean, there is --

MR. RADLINSKI: No, no. It says specifically for existing operating reactors.

MEMBER APOSTOLAKIS: Well, but since we like it for existing reactors, why don't we like it for future reactors?

MR. RADLINSKI: We do.

MEMBER APOSTOLAKIS: Yes.

VICE CHAIRMAN SIEBER: All you need is a rulemaking.

MEMBER APOSTOLAKIS: And that's such a major problem.

MR. RADLINSKI: It takes two years to wait. Then we can do that.

VICE CHAIRMAN SIEBER: Two years. You need an SMR to start one.

MEMBER APOSTOLAKIS: Well, but then, again, it seems that two designs we have certified already have a fire PRA that wouldn't upset anybody because --

VICE CHAIRMAN SIEBER: They wouldn't be upset.

MEMBER APOSTOLAKIS: Yes. It wouldn't upset anybody. And it would be the good way of doing business.

VICE CHAIRMAN SIEBER: Pretty easygoing.

MR. WEERAKKODY: Yes. I can't give you a complete full answer on this issue, but I know I suspect we are kind of talking about is this a policy issue that's under consideration in the new reactor space?

I know the ACRS has its -- what I'm saying is like Bob is up there. And we are kind of parroting what the current policy is as we know it from the new reactor folks. So I don't know whether we can solve it in fire protection.

For example, even if we agree with you that we should require fire PRAs for all new reactors, it's not under the purview of the Fire Protection Branch. But I have heard from the grapevine that you are interested in this issue in other forums.

MEMBER APOSTOLAKIS: Who is raising the issue?

MR. WEERAKKODY: This is just on new reactors. Yes.

MEMBER APOSTOLAKIS: We are raising it?

MR. WEERAKKODY: That's what I --

CHAIRMAN SHACK: In PRA in general.

MR. WEERAKKODY: In PRA in general. So what we are doing, Dr. Apostolakis, is we are following, as opposed to leading, that policy in the fire protection area.

But in the meantime I think what Bob is

saying is he is also the lead for his ESBWR. And he knows 805. He knows the new reactors. From a safety standpoint, the new designs are taking care of the safety business by keeping things in separate rooms.

The only place they bring things together, the cable is using the control room and in the containment. So we are looking at core damage frequencies like 100 times lower than our current operating plants.

MEMBER APOSTOLAKIS: But even if the vendor had included a fire PRA in the design certification application, this implies that the utility that will have a new reactor doesn't necessarily have to go to NFPA 805. That's what it says. It can if they want, but they don't have to.

CHAIRMAN SHACK: It's performance-based.

MEMBER APOSTOLAKIS: My problem with this is that -- and maybe you're right, Sunil, that it's not your business to do these things, but we have lived with a very strange situation so far since 1998 for existing reactors because of the license issue.

But to perpetuate this for new reactors and have these parallel systems forever doesn't sound to me like it's a rational way to proceed. And maybe it's not your job to do that but certainly I think the

Committee's job.

VICE CHAIRMAN SIEBER: But that becomes a policy issue. And I think that it's fair for us if we believe it to recommend to the staff that they consider developing a policy issue. But that's the way a rulemaking would start.

MR. WEERAKKODY: If I may, one thing with respect to 805, we specifically excluded new reactors from 805 because, even though concept-wise, you know, risk-informed, performance-based is okay for new plants as well, it's kind of like the get-by rule, so to speak.

We build a plant. And we want to fix the plant using risk-informed because if you think of the reg guide and the thresholds we applied in the core damage frequency changes that allows self-approval, for the new reactor, it's way too liberal in a sense because they start with a much advanced, much lower core damage frequencies.

Now then you run into another policy issue. Should we be holding new reactors to higher safety standards? So if there is a need to risk-inform new reactors, we should be looking at 806, not 805.

MEMBER APOSTOLAKIS: Well, yes. That's a

detail as far as I'm concerned. And I suspect the reason why 805 did not refer to new reactors is this fear of not putting something there that you don't have to when you approve a document. It's always, you know, focus on the immediate problem and don't say anything about 20 years from now.

As a philosophical issue, though, it seems to me that this is a good opportunity to go with a new system, which a lot of the utilities with existing reactors acknowledge is a good system, right?

MR. WEERAKKODY: Yes.

MEMBER APOSTOLAKIS: In fact, how many plants now, units?

MR. WEERAKKODY: Forty-two.

MEMBER APOSTOLAKIS: Forty-two out of --

MR. WEERAKKODY: A hundred and three, 104 when Browns Ferry starts.

MEMBER APOSTOLAKIS: So that is really my comment on this.

VICE CHAIRMAN SIEBER: Why don't we continue on with your remaining slides?

MR. RADLINSKI: Okay.

MEMBER APOSTOLAKIS: But, again, a fire PRA should receive a peer review to the extent that adequate industry guidance is available. So if I don't have a fire PRA, what do I do? Do I get a peer review or something else?

VICE CHAIRMAN SIEBER: There is nothing to review if you don't have it.

MEMBER APOSTOLAKIS: What?

VICE CHAIRMAN SIEBER: There is nothing to review if you don't have one.

MEMBER APOSTOLAKIS: You don't review the fire PRA. But then I'm doing something in lieu of that. And I would like to know, would there be a peer review for that alternative? In other words, this sends a message that if you dare go into a fire PRA, we're going to hit you with 100 requirements to try to discourage you from doing it.

VICE CHAIRMAN SIEBER: I think it is far easier to do a PRA of any set and get it peer-reviewed than it is to build architectural features into your plant. And that's really the choice you have.

You know, you have to do all of your thinking up front in the design stage if you want to avoid having to take the route of risk-based fire protection. It's still a policy issue.

MEMBER APOSTOLAKIS: It is. It is. But we are sending the wrong message, it seems to me, here.

CHAIRMAN SHACK: There's no other to send, George. You wouldn't have a PRA without a peer review. A peer review of a deterministic program makes a whole lot less sense. I mean, it's perfectly sensible.

VICE CHAIRMAN SIEBER: And that's true probably for all PRAs. I still would like to move on --

CHAIRMAN SHACK: We had better move on.

VICE CHAIRMAN SIEBER: -- and be no later than the fuel folks left us.

CHAIRMAN SHACK: We're taking up George's subcommittee report.

MEMBER APOSTOLAKIS: What?

CHAIRMAN SHACK: Onward.

MR. RADLINSKI: Right. The next comment had to do with new reactors and the guidance that we have provided that they should be maintained safe for all modes of operation.

This entire slide is a summary of their comment, basically to say to delete the guidance that addresses fire protection for non-power operation.

Their basis is that the staff has already approved new designs without disposition, that passive shutdown plants would have to evaluate fire effects on active systems that are used when the plant is too cold for passive cooling.

VICE CHAIRMAN SIEBER: If you don't do anything, the plant will become warm enough for passive cooling.

MR. RADLINSKI: You are getting ahead of me here.

VICE CHAIRMAN SIEBER: Okay. And if there is a requirement or guidance by the NRC, the comment is that the NRC should provide the specific method of analysis that the industry should use to address this.

And, finally, they made the comment that the staff was directed to cease activity on the shutdown rule in 1997. I still haven't figured out what that has to do with this, but -- so our response is basically plants have to have a fire protection program that maintains plant safety in the event of fire in all modes of operation. That's fundamental. Okay?

If you want to find bases in the regulations, 50.48(a)(2)(iii) requires that the means to limit fire damage to structures, systems, and components is important to safety so that the capability to shut down the plant safely is ensured. That means keeping a safe shutdown.

Last, but not least, 50.59. We talked about this in the last meeting. Again, we believe that it would be appropriate to put fire protection back under 50.59.

The Commission has said they do not like the idea of a separate license condition for fire protection, no adverse effect approach to evaluating changes. 50.59 is good for the rest of the planet. It should be good enough for fire protection. So we are proposing to do that.

Okay.

VICE CHAIRMAN SIEBER: Is that it?

MR. RADLINSKI: Yes.

MEMBER APOSTOLAKIS: I have one.

VICE CHAIRMAN SIEBER: George?

MEMBER APOSTOLAKIS: Yes. Again, there is a statement. There is a discussion of the self-imposed station blackout somewhere there on page 19. And there is speculation.

The risk of self-imposed station blackout may greatly exceed the actual risk posed by the fire. And the licensee should consider the risk carefully when evaluating the plant safe shutdown design and procedures. How are they going to do this if they don't have an estimate of the risk?

And that, in fact, we go on and say, "However, acceptable operator manual actions that are implemented in accordance with" such and such and such and such may present a lower risk than the self-imposed station blackout approach. And I'm trying to understand how in a deterministic world a utility may decide that one or the other represents a lower risk.

MR. RADLINSKI: First of all, we did water that down a bit. We took out the word "greatly." I don't imagine that answers your question.

(Laughter.)

MR. WEERAKKODY: This is Sunil Weerakkody again.

VICE CHAIRMAN SIEBER: That solved that problem. I think maybe I can address this a little bit. You know, some of these things in the absence of a PRA, which probably aren't going to do as you discover a fire in certain areas made by engineering judgment or operator judgment as to "Do I want to cope with a self-induced station blackout or do I want to go and put out a fire the size of a wastebasket?" And so it becomes a judgment call in those clear-cut cases.

Beyond that, I think that you are right, George. You would have to do some kind of analysis for the big events where the risk is not well-defined. But just undergoing a station blackout is an operator's challenge.

MEMBER APOSTOLAKIS: And then there is another statement. New reactor design should not rely on self-imposed station blackout to mitigate potential fire damage to safe shutdown systems. Is that a policy issue or is it a technical issue or --

MR. WEERAKKODY: Even though you don't have numerical calculations to show that inducing a station blackout is not a good thing, there is overwhelming knowledge that that is not a good thing to do. I mean, it is kind of almost like common sense.

Why would you want to take out your operating equipment intentionally because you want to be in the licensing basis. We have had to limit that because the regulation does not, the current regulation does not, prohibit that.

In some of the cases, such as this, what we have done is we have basically told the new plants, "Please don't design your plants to rely on that kind of mitigation. It just doesn't make sense."

VICE CHAIRMAN SIEBER: You are blacking

out the plant to avoid some spurious operation, which is pretty drastic.

MR. WEERAKKODY: I mean, you could confirm with risk verification that that is, in fact, the case and say how big it is, but just to say that I'm going to kill these or I'm going to turn all of these off so that they don't get damaged by a spurious actuation --

VICE CHAIRMAN SIEBER: It is my understanding that few plants have that as a provision --

MR. WEERAKKODY: That's correct because that --

VICE CHAIRMAN SIEBER: -- in some fire scenarios.

MEMBER ARMIJO: Has anybody ever done it?

VICE CHAIRMAN SIEBER: No.

MR. WEERAKKODY: Do you mean in actual situation?

MEMBER ARMIJO: In real.

MR. WEERAKKODY: I don't know the answer, but we do know that in some plant procedures, they rely on it. Whether they actually have had a fire to do it I do not know.

MEMBER POWERS: I think, in fact, it has been done, Jack.

VICE CHAIRMAN SIEBER: Where? In the United States?

MEMBER POWERS: Yes, in some U.S. plant. For some reason, Pilgrim comes to mind, but I don't know that for a fact.

VICE CHAIRMAN SIEBER: I don't know. I think it would be a good thing to find out.

MEMBER APOSTOLAKIS: So for a clarification question, for new reactors, if they don't go the risk-informed approach, appendix R applies?

MR. RADLINSKI: No, no. Appendix R doesn't apply to plants licensed after '79 technically. But the guidance is very -- I mean, it's like appendix R. It's --

VICE CHAIRMAN SIEBER: I think that we have pretty much come to a conclusion of the formal presentation part of the meeting. My personal opinion is I read through all of these documents and particularly the questions and answers. I think both the industry, including NEI and other licensees, did a pretty good job of supplying comments. And the staff did a pretty good job of responding to those.

I understand there is an NEI member here. And if anyone would want to make a statement, they can do that now. If not, Mr. Chairman, I turn it back to you.

CHAIRMAN SHACK: The next item in our agenda is a subcommittee report from George on our ESBWR Subcommittee. If you would like to say a few words?

VICE CHAIRMAN SIEBER: Does he know that?

CHAIRMAN SHACK: He does.

MEMBER APOSTOLAKIS: Are we writing a letter on this, by the way?

CHAIRMAN SHACK: No.

VICE CHAIRMAN SIEBER: You can have added comments if you'd like.

MEMBER APOSTOLAKIS: Thank you, Jack. I know I can.

MR. RADLINSKI: Is there a take-away that we assume you're going to approve the --

MEMBER APOSTOLAKIS: What?

MR. RADLINSKI: Is there a take-away that we assume you're going to approve the issuance of the reg guide or --

MEMBER APOSTOLAKIS: There is a question for you.

CHAIRMAN SHACK: That's a Committee decision.

MR. RADLINSKI: May I conclude from your comments that the Committee will approve the issuance of the reg guide?

VICE CHAIRMAN SIEBER: Watch your mail.

(Laughter.)

MEMBER APOSTOLAKIS: You will get some sort of a letter.

VICE CHAIRMAN SIEBER: I can only tell you what I think right now.

9) SUBCOMMITTEE REPORT

MEMBER APOSTOLAKIS: Okay. We had a meeting on December 14 and 15.

CHAIRMAN SHACK: We can go off the record for this.

MEMBER APOSTOLAKIS: Pardon me?

CHAIRMAN SHACK: Yes. We can go off the record for this.

(Whereupon, a luncheon recess was taken at 11:38 p.m.)

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

(1:06 p.m.)

10) WOLF CREEK PRESSURIZER WELD FLAWS

CHAIRMAN SHACK: Our first presentation this afternoon is on the Wolf Creek pressurizer weld flaws. And our cognizant member for that is Sam Armijo. Sam, I'll turn it over to you.

10.1) REMARKS BY THE SUBCOMMITTEE CHAIRMAN

MEMBER ARMIJO: Okay. Mr. Chairman, we're going to have an informational briefing this afternoon related to the October 2006 indications of potential cracking at Wolf Creek.

We will hear from representatives of the staff as well as from Duke Energy and NEI. We're not expected to write a letter or make any decisions, but we are free to ask as many questions as we think we need to understand this.

With that, I would like to turn it over to -- I think it's Mr. Sullivan who will start out for NRR.

MR. SULLIVAN: Thank you very much.

MR. BATEMAN: Excuse me. Ted, before you get started, I would just like to add one more thing. This is Bill Bateman from the staff. We do have a subcommittee meeting scheduled for February 21st, at which point we will have a lot more time to talk about details here -- I know you have only got an hour for us now -- and then a full Committee meeting subsequent to that in March.

MEMBER ARMIJO: And also I think we have someone on the phone, but I'm not positive. Is there?

CHAIRMAN SHACK: I don't know.

MR. LUPOLD: Our understanding is that our contractor, Dave Rudlin called.

MR. RUDLIN: I'm here.

MEMBER APOSTOLAKIS: Who are these people?

MR. LUPOLD: Dave Rudlin is a contractor that we have utilized to evaluate some of the flaws that we discovered at Wolf Creek.

MEMBER APOSTOLAKIS: Are you NRC yourself?

MR. LUPOLD: I am Tim Lupold. I'm with the NRC.

MEMBER APOSTOLAKIS: You have to speak to the microphone, though, because --

MEMBER ARMIJO: Okay. Well, just as long as the folks on the phone just please put their phones on mute so we don't hear any kind of background.

With that, Ted, it's all yours.

10.2) BRIEFING BY AND DISCUSSIONS WITH REPRESENTATIVES OF THE NRC STAFF

MR. SULLIVAN: My name is Ted Sullivan. And I work in the Division of Component Integrity. And I've been working on this Wolf Creek law issue since about November time frame.

I wanted to set out some very brief background. I know this is kind of industry stuff, but I thought it would be appropriate to help put the Wolf Creek information in a little bit of context. And at the subsequent meeting, I expect that either industry or ourselves will talk about this more.

The context for these inspections is an industry "mandatory program" under some guidelines that were issued by NEI. This particular program is very customarily referred to as MRP-139. And it deals with inspection and mitigation of dissimilar metal butt welds and reactor coolant system of PWRs. It provides, among other things, guidance for volumetric and visual inspection of alloy-82/182 butt welds.

It is over and above what is required by the ASME code in that it requires -- in the industry context, I'm using the word "require" -- inspections that are more frequent than those required by the ASME code. And the whole program is somewhat oriented around temperature in that, for example, the pressurizer weld locations need to be inspected first and most frequently.

So it was in that context that these indications or flaws at Wolf Creek were found. This licensee was performing inspections of the dissimilar metal butt welds in the nozzles of the pressurizer.

And these indications were found as part of inspections that were done prior to applying weld overlays, which was their plan all along. And I'm going to talk about that more in subsequent slides. We were notified of it in mid October by an event notification.

So flaws were found in three of I guess six nozzles. And I'll get into them one by one. In the surge line, there were three flaws found. They were circumferential in orientation.

They are of varying sizes. One, the first one, has an arc of about 38 degrees; the second about 21-degree arc; and the third one is a much smaller, about 7 and a half-degree, arc.

This weld was last examined in 1993 using techniques that predated the performance demonstration initiative qualification program. I want to say a little bit about the qualification of the procedure and the examiner. The procedure that was used was a manual procedure. It was qualified for flaw detection and length sizing.

The examiner was qualified for detection. He had apparently not gone through or passed -- I don't know which -- the qualification for length sizing. Notwithstanding, readings were taken for informational purposes on length and depth and all the readings were confirmed by a person from EPRI. And that note, which will appear on some subsequent viewgraphs, is true for all of the welds examined.

MEMBER ARMIJO: Was the EPRI person an expert or did you --

MR. SULLIVAN: The EPRI person was a person who administers the PDI qualification exams.

MEMBER ARMIJO: But he's experienced?

MR. SULLIVAN: I would say he was very experienced, and he was an expert. I just can't call him qualified because EPRI doesn't qualify its own people. They administer the exams.

MEMBER BONACA: The 13 years between the last volumetric examination, is normal, the long period of time?

MR. SULLIVAN: I'm not sure why there was such a long period of time. It does seem like a long time. It's more than an interval.

MEMBER BONACA: Yes.

MR. SULLIVAN: That's a good question. That's not something we asked. Do you know?

MEMBER CORRADINI: Well, if I could address that, the requirement would be to inspect it once every interval. And the ASME section 11 gives latitude to defer some exams from one period to a next. So it's ten years plus or minus is what the exams would be. So it's not unheard of to have 13 years between subsequent exams.

MR. SULLIVAN: Okay. On the relief nozzle, there was a very large flaw. It was a 170-degree arc. And on the safety nozzle, there was one flaw also. It had about a 55-degree arc.

MEMBER ARMIJO: I've seen prior presentation material that the staff has issued, maybe a month or so ago. And I've seen numbers that are higher, like 11-inch cracks or indications, as opposed to 7.7. What is going on?

MR. LUPOLD: The numbers that you're referring to would be the lengths of the flaws, as projected on the OD of the pipe. This is these numbers that you're seeing right here --

MEMBER ARMIJO: ID.

MR. LUPOLD: -- would be the length of the flaws on the ID.

MR. SULLIVAN: When we initially got the data, it was over the telephone. And we weren't clear where these links were. We thought they were on the ID. They subsequently clarified it was on the ODs. So we had to do a little conversion.

Okay. Our concerns with these inspection results were that they were the first large multiple circumferential flaws identified. Previous circumferential flaws have been identified, but these were large. We found a very large flaw. And we found multiple indications in one of the nozzles.

The expectation was to see smaller flaws and see axial flaws. Predominantly the inspection data shows more often you get axial flaws than circumferential. And, of course, the concern with circumferential flaws is it can lead to rupture, as opposed to the concern you have with the axial is that it's much more likely to just lead to leakage.

And our concern with the large flaws and the multiple flaws was that it seemed to us to increase the need to complete the baseline inspections on a timely basis.

So we did fracture mechanics evaluations of this data. We took it as though it was axial, actual, even though we couldn't confirm it. We didn't change the sizes. We just used the information data to do analysis.

The analyses were done in such a way as to basically work the problem backwards to try to get an estimate of when the cracks might have initiated. And then we worked the problem forward to get an estimate of when the flaws could lead to leakage if they were left in service, if they had been left in service. And we estimated times to reach critical flaw size, again, if they had been left in service.

We analyzed the flaws in all three nozzles. We didn't assume that the flaws in the surge line interacted. We just picked the largest of those three flaws. We calculated time ranges based on three different residual stress profiles, two different fracture mechanics models, and two different through-wall flaw models.

And I think we can talk about that a lot more in the meeting on the 21st of February, but the reason I'm bringing it up now is that 2 times 3 times 2 turns out to be 12 different cases that were analyzed. And that will come up on a subsequent slide.

These were not best estimate calculations. And they're not considered bounding. They were just calculations we did to try to scope the problem.

VICE CHAIRMAN SIEBER: Did you get any clue as to the validity of the leak before a break assumption?

MR. SULLIVAN: Yes. That's where we are going with this.

VICE CHAIRMAN SIEBER: Okay. It breaks first and then leaks.

MR. SULLIVAN: Well, this will come up on the next slide. On this slide, which talks about the results for the surge line, in all 12 cases we analyzed, we saw some time between leakage and rupture. And you can see that in the rows of this particular table on this viewgraph.

So that is the salient point, I think, of this viewgraph other than the fact that the times could be fairly short, less than two refueling cycles.

MEMBER MAYNARD: One thing to be pointed out, Wolf Creek did not take credit for leak before break. This was analyzed without taking credit for leak before break for this particular line. So they were not outside their design basis. I think that's important to note.

MR. SULLIVAN: That's true. On this plant, the surge line was not a leak before break, pipe that had not been requested of the staff nor reviewed. And, as with other plants, the smaller nozzles, the safety and the relief lines were never submitted to the staff as candidates for leak before break.

CHAIRMAN SHACK: I mean, those ranges of times don't pass my sanity check, actually. I mean, you know, I would say measured size to leak could be one year to infinity. Initiation to measured size could be -- I would be astounded if it were .3 years. It could well be 16 years.

MEMBER CORRADINI: Which one did you say astounds you?

MR. SULLIVAN: The first one.

CHAIRMAN SHACK: What were the assumptions? Well, maybe that's something we can just wait. I'll just make that comment. We'll wait until we get to the subcommittee meeting.

MEMBER ARMIJO: Even though there was no claim on leak before break, those are pretty big pipes, 15-inch, 16-inch pipes. That's a pretty hefty piece of metal there.

MEMBER MAYNARD: The surge line is a 15-inch line. And then those nozzles are 8-inch lines.

MR. SULLIVAN: In our evaluation of this information, we didn't really give any particular credence to the time. And I think the results of this analysis as I'll get into it really are not surprising. It's not surprising that on the surge line, you would see leak before break behavior.

On the smaller lines, which are not as flaw-tolerant, it's not surprising that you would see rupture turnout in the calculations before leakage. And that really is pretty much how we used the information.

MEMBER BONACA: It still troubles me when I think about what we're saying in license renewal, that a 10-year inspection was good when the plant was 10 years old. Then it's good when the plant is 50 years old. And this is confirming otherwise.

MR. SULLIVAN: Well, I guess the reason we are pretty comfortable with this is that industry has put together a reasonably aggressive program to mitigate these welds. And so in license renewal space, we think that that's really what license renewal is relying on, is the program to mitigate these welds and address PWSCC.

MEMBER BONACA: Yes. This is the problem of the day.

MR. SULLIVAN: That's right.

MEMBER BONACA: Then tomorrow there is going to be some other component. I mean, there has to be a recognition that aging is going to create new flaws. It just is inevitable.

MR. SULLIVAN: Right.

MEMBER BONACA: And I'm just saying that we'll have to reflect on the inspection intervals.

CHAIRMAN SHACK: Yes. Let me ask another question about the inspections. I mean, every section XI inspection now of a welded pipe is going to be done with a PDI-qualified inspector?

MR. SULLIVAN: That's correct.

CHAIRMAN SHACK: Okay. So there will be no more inspections that will be done by anybody that's not through the qualification process?

MR. SULLIVAN: That's true. I mean, you have to recognize, though, that there are PDI supplements to address, at least the cast stainless steel. That problem is still being worked.

CHAIRMAN SHACK: Right.

MR. SULLIVAN: And I think one of the points of this -- and industry will probably make this point on the 21st, but there are a lot of these welds that can't be inspected because you don't have access or you've got materials that are not inspectable. But one of the thrusts of the MRP-139 program is to make the configuration inspectable, even if you have to put a weld overlay, a full-structure weld overlay, on the weld to accomplish that.

CHAIRMAN SHACK: So you can inspect the overlay? You still can't inspect the pipe?

MR. SULLIVAN: Depending on the material, underneath it, you can inspect into the original weld, at least some distance, again, depending on what the adjacent materials are.

Okay. We have kind of covered the point here already, but I'll just get into it briefly. In the leak to rupture row, the fourth row on this table, the important information is in the note. And what it shows is that in 8 of the 12 cases we analyzed, there wasn't any time between leak and rupture.

And, contrasting that with the safety nozzle, we found something similar, although not quite as dramatic, which is that in 4 cases, 4 out of the 12 cases, there was no time between leak and rupture.

And I think that we can discuss this further on the 21st. We're trying to make arrangements to send over to the ACRS the report that our contractor put together that will discuss this in a lot more detail. You can see exactly which assumptions led to which results.

MEMBER ARMIJO: Is your primary assumption that this was PWSCC and that the crack growth rates, you had crack growth rate data that you could use in the analysis?

MR. SULLIVAN: Yes. In this analysis, we treated the flaws as PWSCC, which was the most probable causae that was identified by the licensee. And we used the MRP-115 crack growth rates, which were generated by the industry using a lot of data, both industry data, probably some NRC data, and some Navy data.

MEMBER ARMIJO: Okay. So then you worked back from the time to -- you worked backwards from those. So that left a long period of time for initiation, right?

MR. SULLIVAN: Well, basically this is what --

MEMBER ARMIJO: That's Bill's issue, isn't it?

MR. SULLIVAN: -- Dr. Shack was commenting on, that it shows the possibility that these flaws generated in a non-credibly short period of time.

CHAIRMAN SHACK: I mean, even to do these things, you have to make all sorts of assumptions about how many cracks initiated, you know, whether these cracks are 11 inches long because you initiated 100 short cracks that linked up or there is this one crack that grew that arrested itself going through the wall and then grew around the thing. So you pick a number. I can come through here and give you an analysis that can be just about any number you want.

MEMBER ARMIJO: Or the state of stress. What's the stress where these things are growing?

MR. SULLIVAN: Well, we had to make assumptions about part of that. We used the design loads that came from the licensee and maybe ultimately from Westinghouse. And we used three different residual stress models. So that's where the stress assumptions came from.

Okay. Moving on into some less numerical material, some general observations are that long circ flaws decreased time between leak and rupture. Your flaw tolerance goes down if you start out assuming that you've got long circ flaws to begin with.

And the second observation is basically that smaller diameter welds are less well-tolerant than large diameter welds. And then specifically I think the rest of this slide just kind of reiterates what we just talked about, that the relief line had the least margin based on our analysis, with 8 of 12 cases showing no time between leak and rupture.

The safety line analysis had a shorter flaw. It showed that 4 out of the 12 cases analyzed didn't produce any evidence of leakage prior to rupture. And the surge line, I think in part because of the way we analyzed it, not linking up any of the flaws, we sold it in all cases with some time between leak and rupture. And the shortest time on all of these analyses or most of them, not every single one, or most of them was less than two operating cycles, I think between initiation and failure.

I've got a little treatment here of conservatisms, non-conservatisms, and uncertainties. And it's kind of difficult in this case to try to figure out which box to put some of these aspects in.

Residual stress relaxation is a problem that was worked by industry prior to our last meeting. That's a potential conservatism. The only reason I say "potential" is I think it could vary depending on what residual stress models are used.

The axisymmetric residual stress distribution is generally thought of as a conservatism. That's something I haven't mentioned up until now, but the way the residual stresses are modeled for practicality and possibly also because of lack of better information, they're modeled as axisymmetric. And that's generally viewed as a conservatism, although I don't think it would necessarily be.

There are some potential non-conservatisms in the analysis. Not to overwork this, but we have talked about some of these already. The first one certainly I have talked about.

The pipe loads that we used were not necessarily bounding. We got Wolf Creek-specific numbers. And we're aware they aren't bounding for the industry. The indication sizes may not be bounding. We really don't know what is out in the fleet. The indications we use may be bounding, but they may not be.

The industry recommends and uses the 75th percentile crack growth rate. That's what we used in this analysis. That's not necessarily bounding.

And in terms of uncertainties, I think we have hit on some of these. The residual stress distribution is certainly an uncertainty, no pun intended.

MEMBER APOSTOLAKIS: I don't understand

the statement of the 75th percentile is not necessarily bounding. What does that mean?

MR. SULLIVAN: Well, a 95th percentile crack growth rate would be more conservative. I'm just pointing out that what was used in the analysis was the 75th percentile.

MEMBER CORRADINI: Growth rate?

MR. SULLIVAN: Growth rate, yes.

MEMBER APOSTOLAKIS: But neither one is bounding.

MR. SULLIVAN: That's true. One would be more conservative.

As I think we may get into later, there are 37 units that have not been addressed under MRP-139. That's a little bit just slightly bigger than half the units.

And flaw depth is another uncertainty. As I pointed out before, the flaw depths were measured, but they weren't measured with qualified techniques.

The position that the staff has been developing is based on the thinking that the inspections or mitigations need to be accelerated from the current industry schedule for some plants. I know that statement is a little bit in a vacuum, but if we have time, I'll talk more about what that means.

CHAIRMAN SHACK: You aren't going to give us a hint as to what some plants are?

MR. SULLIVAN: Okay. I'll get into that right now. I said that 37 plants haven't completed their MRP-139 evaluations. There were 19 plants that don't even have dissimilar metal welds.

There are something like 13 plants that up to now have already implemented the MRP-139 inspections or mitigations. Most of them have mitigated. Some have just inspected with an augmented inspection frequency requirement in MRP-139 over that in the code.

There are 26 or 27 plants that are scheduled to do the inspections in 2007. Two thousand and seven is the schedule that was originally in MRP-139 for completing the baseline program. That leaves 9, 10, 11 plants somewhere in there.

The reason I'm being a little bit vague is that it hasn't happened yet. We just have information on what is planned. But somewhere around ten plants are slatted to do the examination after the original schedule in MRP-139, namely in 2008. And they're really the target of this first bullet.

MEMBER ARMIJO: The plants that don't have dissimilar metal welds, are they exempt from this inspection?

MR. SULLIVAN: Yes.

MEMBER ARMIJO: Is there a reason for that?

MR. SULLIVAN: The program is designed to address PWSCC. And PWSCC has only been found to date in alloy 82, 182 welds and alloy 600 products.

MEMBER ARMIJO: And what are these materials? Are those --

MR. SULLIVAN: This program and the Wolf Creek welds only applies to 82, 182 --

MEMBER ARMIJO: Right. No. I'm talking about the 11 that --

CHAIRMAN SHACK: They would be stainless with 308 in all likelihood.

MR. SULLIVAN: No. The 11 plants are 11 plants who have planned to do the inspections in 2008 that all have alloy 82 or 182 welds.

MEMBER ARMIJO: Yes. I got that. I'm going back to the ones that are exempt from this issue.

MR. LUPOLD: Okay. We are referring to the plants that we said don't have materials that are susceptible. And those materials typically are stainless steel materials. Some of those materials could be alloy 52 or alloy 152 also.

Now, MRP-139 actually talked about those type materials. They're considered to be resistant materials. And all MRP-139 would do is have you go back and inspect in accordance with the ASME section 11 program.

MEMBER ARMIJO: Okay. So there is some basis for those materials to be viewed as lower risk or no risk?

MR. LUPOLD: That's correct.

MEMBER ARMIJO: And at the subcommittee meeting, I would like to get more information on why that is true.

MEMBER POWERS: I am not familiar with 152.

MR. LUPOLD: Alloy 152 is a nickel-based alloy which has a much higher chromium content in it than alloy 82 or alloy 182. And having the higher chromium content has demonstrated it is more resistant to primary water stress corrosion cracking and testing that is being conducted on the material.

CHAIRMAN SHACK: It's sort of the weld equivalent of 690.

MEMBER CORRADINI: Yes. That's a very good statement.

MR. SULLIVAN: Okay. Returning to this viewgraph, the second part of our developing position is that we view that enhanced RCS leakage monitoring with action levels to shut down and visually inspect welds would be a very desirable thing to do until inspections or mitigations are completed. And in developing this position, we considered a number of factors.

I think we talked about most of these already. So I think I will just move on to the next viewgraph.

Now, I don't want to in any way shortchange the industry, but we put together a listing of bullets of the industry position. We have lifted these strictly out of their documents. They're going to have time to explain their position more, but I just wanted to lay out a couple of things.

Industry has stated they believe the inspection findings are an anomaly. We don't think we're in the position to treat it as such. And anomalies have been -- inspection findings have occurred in the past that have been ascribed to anomalous behavior. And most of the time they don't turn out to be anomalous.

Industry agrees with an enhanced leakage detection program. I think our differences at this point have to do with action levels and specific time lines for completing action levels and shutting down the plant if that's what it comes to. They have a very good program, but it's not as prescriptive as we would like to see.

Industry is undertaking some non-linear finite element analyses to try to address some differences between industry results and what they think is a more realistic outcome. I'll comment on that in the next slide.

And I think that's probably enough for now. Industry is going to have time to talk about it some more.

MEMBER BONACA: Sorry. The issue, you had some bullets about bounded by plant design basis accident analysis, existing safety analysis conclusions remaining valid. Of course, frequently of the breaks is an element of those analyses. And so somebody will explain why these would be acceptable.

MR. SULLIVAN: I think industry is going to be up in a few minutes. So maybe they can --

MEMBER BANERJEE: I have a question about the finite element analysis. This has to assume some sort of a residual stress distribution, right, when you do this? So what sort of assumptions would be made there?

MR. SULLIVAN: In the analyses that have been done so far, we used three different residual stress assumptions. One of them was an ASME model. It appears in the ASME code. It was pegged to a higher yield stress than the one in the code because the materials have a different yield stress.

The second model is one that was developed by our contractor based on finite element analyses of weld deposition.

MEMBER BANERJEE: When the weld was done?

MR. SULLIVAN: Right. That's my understanding. And the third assumption was no residual stress at all.

MEMBER ARMIJO: Just applied loads?

MR. SULLIVAN: Just applied loads, correct.

MEMBER ARMIJO: That was your longest time, right? And it should have been if it wasn't something --

MR. SULLIVAN: I think it was.

MEMBER BANERJEE: But do these actually bound the situation?

MR. SULLIVAN: No, we don't think they

bound it. That's why I made the statements earlier that these analyses are just scoping analyses in our view. They're not bounding or best estimate. We just tried to do some analyses to show what could happen.

MEMBER BANERJEE: What will industry do to improve this situation or are they going to tell us?

MEMBER ARMIJO: They are going to tell us.

MR. SULLIVAN: Well, I think they are available to answer in more detail, but I think the main thing is that these analyses will remove the constraint that the flaws remain elliptical.

MR. LUPOLD: We should just go right to the next slide.

MR. SULLIVAN: We have some skepticism. This isn't about the analyses. We certainly think it will be interesting. We think it's important work. We're interested in understanding what's going to happen from these analyses. And the NRC is interested in doing some similar work itself.

But in terms of using this for regulatory decision-making, that's kind of another matter. We think that these analyses will basically turn out to just be another scoping study. And they may come up with different results. They may show that you get leak before a break.

But I think the end result would be what we already know. You may or may not get leak before a break. I think that unless these analyses could rule out rupture prior to leakage, I don't think they're going to help us in regulatory decision-making.

So that's kind of the point of the first bullet. I already made the second bullet. We talked about that. We don't consider these results anomalous. We don't think that's a position that experience proves out with previous inspection results. And, you know, that's not something we would ever do.

I previously kind of alluded to our concern with industry's leak-monitoring program. It's an excellent program, but it doesn't have time constraints for implementing actions. And it doesn't require shutdown depending on what could be found.

MEMBER BANERJEE: How do they monitor these leaks?

MEMBER CORRADINI: Typically RCS leakage is measured just through a mass balance for the reactor coolant system.

MEMBER BANERJEE: In the system itself, right.

MEMBER CORRADINI: Yes, in the system. It's measured at every plant at least every 72 hours. Some plants will do it 48 hours. Some plants will do it every 24 hours.

MEMBER BANERJEE: Well, what are the thresholds of detection here?

MEMBER CORRADINI: Industry may be able to answer this question a little bit better, but typically you could measure into the hundredths of a gallon per minute leakage.

MEMBER BANERJEE: Hundreds of gallons.

MEMBER CORRADINI: Hundredths, .01.

MEMBER BANERJEE: Hundredths?

MEMBER CORRADINI: .01 galloon per minute.

MEMBER BANERJEE: So you can actually monitor all the inflows and outflows and everything down to .01 of a gallon?

MEMBER CORRADINI: It's monitored over a time period. So you collect how much leakage you have over like a 24-hour period. And then you do the mass balance. And you can come up with changes of a couple of hundredths of a gpm, you know, from one day to the next. You can see that in the calculations. And typically, though --

MEMBER BANERJEE: It depends on the

accuracy with which you can measure various --

MEMBER CORRADINI: Yes, it does. It depends on the accuracy of your measuring instruments and, you know --

MEMBER MAYNARD: This has tech specs associated with it, not only the instrumentation but the requirements to do it. In addition to being able to do the mass balance and leakage that way, if you get a leak in this part of the system, you also have radiation monitors and you have containment temperature, containment pressure. You have a number of other things that are going to alert you to a leak from an area like this.

MEMBER CORRADINI: Right. You also have your --

MEMBER BANERJEE: So just to go back to this mass balance thing, when we had these leaks in alloy 600 and alloy 600 welds, were such leak-monitoring programs underway to do a mass balance and detect the leaks?

MEMBER CORRADINI: Yes. Utilities have used the mass balance for some time period. A very, very small leak from an alloy 600 weld or an alloy 82 weld will probably not be detected in a mass balance.

MEMBER BANERJEE: So with Davis-Besse,

would this have been detected or not?

MEMBER CORRADINI: I hate to speculate on that because I don't really have the background information on Davis-Besse to really answer that question.

MR. SULLIVAN: We've done some calculations of situations where a flaw goes from just a pinhole. A circ flaw, for example, goes from a pinhole to a longer flaw assuming that the overall length is short enough to remain stable.

And we believe you get enough flow out of a long, stable -- well, not a long -- a short -- can anybody help me here? Dave?

MR. RUDLIN: Yes?

MR. SULLIVAN: You did some calculations of leakage.

MR. RUDLIN: Right.

MR. SULLIVAN: Do you have some idea of how long the flaw might have to be before you would see something on the order of, say, .1 gpm?

MR. RUDLIN: It depends on the load and monitoring factors.

MR. SULLIVAN: Did we do these calculations assuming the Wolf Creek loads?

MR. RUDLIN: Yes, yes, but we didn't do

any calculations from obtainable type loads. We did them for ideas like through-wall crack types.

MEMBER CORRADINI: Dave, I was going to ask you. Is it safe to say that a leak rate would be a high enough volume to detect before we encroached rupture of a pipe?

MR. RUDLIN: The problem is that when you have just the flaw just breaking through, the time between the first pinhole to the time it becomes an idea like a through-wall crack, it's probably going to be very small. The growth in that little ligament area is going to happen very, very quickly.

In the relief line type of calculation, a surface crack was actually unstable. And so before even leakage, the surface crack would have failed, creating a large opening that would have been longer than the critical through-wall crack size.

That was a specific unique case, I think, with the relief line. I think in most of the other cases, where the surface crack was stable until leakage, there probably would be enough time for detection before you can get the critical through-wall cracks stopped.

MEMBER ARMIJO: Yes. Well, those kind of details I think we have to address in the subcommittee meeting. But I just want to ask one question. I'm going to ask industry the same thing. Are you convinced that these are cracks -- it's as simple as that -- these are cracks and not just some other anomaly, bad NDT signals or --

MR. SULLIVAN: I don't think we can say that we are convinced because there is no destructive examination data.

MEMBER ARMIJO: Right.

MR. SULLIVAN: But the analysts called it as a multi-faceted indication, which this is the sort of indication you can get from stress corrosion cracking, although you don't necessarily only get it from stress corrosion cracking.

I think the position of the regulatory agency is we have to treat it as stress corrosion cracking. It's the only sensible position for us to take. We cannot be in a position of saying, "Well, we don't know for sure. So we're going to treat it as though it's not cracking."

MEMBER ARMIJO: I know that Wolf Creek did not take a sample for metallographic examination. Does anyone in the industry intend to do that if they find something so you can put it to bed that this is really PWSCC and not something else?

MR. SULLIVAN: I think that maybe Alex or someone --

MEMBER ARMIJO: Okay. Fine.

MR. SULLIVAN: -- can answer that question in the next segment.

MEMBER ARMIJO: Any other questions?

(No response.)

MEMBER ARMIJO: Okay. Well, I think the next speaker is -- where did we have our little -- who is the next speaker? Is it Alex Marion? Yes. NEI.

MR. HAMMER: Sam, I understand that Duke, the Duke representative is not here but that Alex Marion is going to make the presentation.

MEMBER ARMIJO: Okay.

MR. HAMMER: NEI.

MR. MARION: Good afternoon. My name is Alex Marion. I'm the Executive Director for Nuclear Operations and Engineering at NEI. Mike Robinson was scheduled to give this presentation, but he was unable to attend because of weather conditions in the south.

I have with me Glenn White from Dominion Engineering, one of the technical consultants that the industry is using; and also Jim Riley, who is the Director of Engineering of NEI. Hopefully Mike Robinson is on the telephone. Mike, are you there?

MR. ROBINSON: I am here, Alex.

MR. MARION: Good. And we also have Christine King from EPRI on the phone as well.

MS. KING: That's right. I am here.

MR. MARION: So I have a team of four people to keep me out of trouble.

MEMBER ARMIJO: Well, these are EPRI logo charts.

MR. MARION: Yes.

MEMBER ARMIJO: But you are presenting for everybody.

MR. MARION: Yes. The EPRI program, as Ted Sullivan indicated, comes under the auspices of an industry-wide initiative that was undertaken by the Nuclear Energy Institute. And the EPRI materials reliability project is one of the issued programs that come within that program or within that initiative. And their primary focus is on pressurized water reactor piping systems and components relative to degradation.

What I would like to do is offer the industry perspective relative to this question of the generic implications of the Wolf Creek inspection findings. Let me just say that our position is that the industry has put forth a very proactive management program to assess the condition of alloy 82, 182 butt welds and PWR primary systems. And we have developed that with a focus on the more susceptible areas.

Basically the first phase involves the welds located in the vicinity of the pressurizer. And we have reevaluated the schedule and the focus of our program, which is documented in MRP-139. And we do not believe that we need to accelerate the schedule.

So fundamentally our first principle is that we feel that the bases for MRP-139 inspection program as well as the safety analysis that was developed to support that inspection program remain valid in light of the findings at Wolf Creek.

MEMBER ARMIJO: When that program was set up, were you basing that on the existence of axial cracking or did you have circumferential cracking also in mind when you came up with these?

MR. MARION: I believe predominantly axial cracking based upon the available information from laboratory data as well as field experience on the kind of cracking phenomena we have been experiencing on an international basis. And all of that was factored into the program that we have developed thus far.

I don't know if Mike or Christine want to elaborate on that at all.

MR. ROBINSON: Just a quick comment, Alex. When we put 139 together, we did assume axial cracks, but we also went back and accounted for the fact that certain cracks were very much a possibility. So 139 considers the possibility of both and circ cracks.

MR. MARION: Okay.

MEMBER ABDEL-KHALIK: Just to ask a question about this enhanced leakage monitoring program, what is being proposed here? Tightening tech spec limits on unidentified leaks or --

MR. MARION: I will speak to that in a little more detail later in the presentation if I can defer that question.

MEMBER ABDEL-KHALIK: All right.

MR. MARION: Basically, as we indicated, the pressurizer locations were the more susceptible locations based upon the knowledge that was available at the time that we put the program together. And clearly they have our highest priority.

Fundamentally with regard to the Wolf Creek findings, we think they're anomalous because they're not validated or confirmed by any of the previous findings in basically the worldwide experience to date.

I will elaborate a little bit more on the leakage monitoring programs, as I indicated previously, but we think this is very important because we as an industry believe safety needs to be maintained and it is being maintained. And one of the key aspects of doing that is to have an effective responsive leakage monitoring program.

MEMBER ARMIJO: Just to make sure I understand, you said you don't think these are valid. Does that mean you still have doubts whether these are cracks, that there may be just some NDT anomaly?

MR. MARION: Yes. Hindsight being 20/20, we wish we had taken a boat sample at the time, but we didn't.

MEMBER ARMIJO: Me, too.

MR. MARION: And so, as the staff indicated, they feel that they're in the position where they have no choice but to take a very conservative stance relative to the inspection findings of Wolf Creek. And because of their uniqueness, we don't feel that we have to take the same position.

There are discussions going on --

CHAIRMAN SHACK: That doesn't inspire confidence in your inspection program, though, if you are that skeptical about the results.

MR. MARION: Well, the reason we're skeptical about the results is because there wasn't a sufficiently comprehensive NDE conducted to really determine the depth size, et cetera. And that's a big question that remains.

And the uniqueness of the indications on -- was it five indications? -- basically averaged anywhere from 22 to 33, 35 percent through all going circumferentially around the pipe. And that has never been seen before at all.

CHAIRMAN SHACK: But, I mean, that is fairly typical of a crack in a weld. You know, we have core shrouds cracked partway through by the foot. You know, there must be -- well, make it the kilometer.

MEMBER ARMIJO: Yes. In BWR pipe cracks, we have had multiple indications and --

MR. RILEY: This is Jim Riley, NEI. A couple of the reasons that we felt this was unusual is that there was no axial component to these. And where we have been predicting axial all along kind of being inspected degradation pipe, there was no axial component here.

And, in addition, we found all of these

indications at basically the same place, through-wall, which is a little curious also because if they are cracks and if they are growing rapidly, to find this many at basically 20-some percent through-wall, all at a snapshot in time, is unusual.

MEMBER ARMIJO: Not for BWR piping. We have certainly seen that kind of circumferential cracking, that depth, also hard sizes on BWR pipe cracking and --

MR. RILEY: Did you find them all about the same depth at the same time?

MEMBER ARMIJO: Sure, sure.

CHAIRMAN SHACK: That is exactly what I would expect, actually, from stress corrosion cracks in a pipe weld.

MR. RILEY: They would all be growing on a basis we started at the same time growing at the same --

CHAIRMAN SHACK: No. That they slow down as they go through the weld. And now the guess is, have they stopped or have they just slowed down?

PARTICIPANT: They're growing laterally.

CHAIRMAN SHACK: So they're going to around and spread and initiate around. So you're going to get long cracks growing slowly through the wall. But now the question is, how slow is slow and how long?

MR. MARION: Well, if I am not mistaken, we're talking about different materials and different forms of degradation.

MEMBER ARMIJO: I don't think so. They're definitely different materials.

CHAIRMAN SHACK: It is a residual stress, and it is a stress corrosion crack.

MEMBER ARMIJO: Unless you're sure it's not a stress corrosion crack by virtue of that you don't have confidence in your NDT methods, then you've got to assume that it is, I guess.

Go ahead.

MS. KING: This is Christine King. I would like to offer one other point relative to this being an anomalous indication. We have recently taken samples out of the North Anna Unit 2 reactor vessel head and cut into them.

And those were indications that were called large circumferential flaws as well. When we actually cut into those flaws, what we found was a repair that had intruded into the nozzle. And that's what was actually found and called by the NDE.

We had similar -- it had facets and things like that. So it's not that we don't have confidence in our NDE, but sometimes you do get a repair that by a UT method looks as if it is a PWSCC flaw.

MEMBER ARMIJO: Well, let me tell you I was involved in BWR pipe cracking at the very beginning of that problem. And I can't tell you how many times people said we had an anomalous finding, one of a kind, and it turned out to be a major problem for the industry. So I think the prudent thing to do is assume they're real until you prove that they're not real cracks. And you're going to save yourself a lot of money in the long run.

MR. ROBINSON: Alex, just one other comment. You know, the cracks at the indication at Wolf Creek aren't the first indications of cracking in these pressurizer nozzle locations.

There are, I think, if memory serves me correctly, about 20 worldwide other occurrences where cracking has been found in these locations. And when you go back and look at the indications that were reported from the other 20 or 17 locations, you find that most of those were axial in orientation.

You also find that where there were other circ cracks, they were much smaller in scale. But they also had an accompanying axial component, which, again, there were other reasons why we believe that part of what we're seeing here at Wolf Creek really doesn't fit the model of what we have seen elsewhere.

MEMBER ARMIJO: Yes, but nature doesn't feel it has to fit your model. It does what it wants. And then your model has to fit the data. Anyway, go on.

MR. MARION: That's a point well-taken. Thank you. I would like to move on with the presentation material because I only have 40 more slides to go in the next 5 minutes.

All pressurized water reactors will have inspected or mitigated pressurizer locations by their next normally scheduled refueling outage, which is less than 16 months away. Let me offer another perspective. And we'll get into details on this when we have the subcommittee meeting.

If you look at the timeline of activity and when MRP-139 was issued where plants were in their outage cycles, regardless of whether 18-month or 24-month cycle, and you look at the timeline and you could see clearly that not everybody was going to complete the inspections by the end of 2007, we recognize that on the front end. And the December 31, 2007 was from the industry perspective a reasonable date to basically put on the table as a goal to be achieved, but we recognize everyone couldn't meet that gaol.

CHAIRMAN SHACK: When will everybody meet that goal under your plan?

MR. MARION: The utilities that have planned to do inspections in 2008 have evaluated their justification and rationale for not meeting the goal. And that evaluation has been reviewed independently by the utilities.

MR. ROBINSON: Alex, a more direct answer, right now there are nine plants that are planning to do either inspection or litigation in the spring, in the Spring 2008. There is one plant that has an outage scheduled the first week of February 2008, three plants that have outages scheduled for the first week of March of 2008, a fourth plant that has outages scheduled in April of 2008. And the last plant that has an outage to do with this particular material and this issue occurs in early June 2008.

CHAIRMAN SHACK: Thank you.

MR. MARION: All right. One other thing that had come up is the NRC was concerned about not having specific information on what utilities have completed relative to this inspection program, nor do they have complete information relative to what utilities were planning to do under this program.

And so all the utilities have agreed to submit letters to the NRC. And those letters were to be in by the 31st of January articulating the status of their inspection results or mitigation results to date as well as their plans going forward.

And to date all plants have completed bare metal visual examinations. And a number of them have already completed volumetric examinations.

This graphic represents the inspection mitigation plans by plant. We already talked about the utilities that do not have the susceptible material. There are four plants that have replaced their pressurizer. And the material that they're using in the weld is nonsusceptible material.

Inspections have been completed at two plants thus far. Mitigation has been completed at 11. And I'm not going to go through all the statistics because of lack of time. You have that information.

But I think this represents a very disciplined, balanced approach to executing this inspection program.

MEMBER ARMIJO: If any of these people find circumferential cracking of a reasonable size, is there any new requirement to get a bolt sample so you can confirm what the mechanism is?

MR. MARION: That's an excellent question. One of the things that we're doing with this program is conducting lessons learned after each of the outage campaigns.

And we just completed evaluating potential lessons learned from the Fall 2006 outages. We're going to do the same thing in the spring of this year as well as possibly in the fall of this year.

And we clearly recognize that we needed to improve on the communication, the communication from the individual utility at the time that they find an inspection indication or inspection result that calls into question some of the fundamental assumptions we have already made.

And we have positioned the industry resources to be responsive to that particular utility so they can do an evaluation and provide some recommendations on what the utility should do going forward. And we're trying to set that up so it's very timely.

There were communications that were conducted as a result of the Wolf Creek inspection findings. But, quite frankly, we feel that we can improve on that process. And so we have that in place.

I will never say never, but I can tell you that we're putting whatever checks and balances we need going forward so that we can identify these findings right away, communicate them to the right technical resources within industry, and then provide some guidance to utility in the middle of an outage so they can make an informed decision.

CHAIRMAN SHACK: How about a standby team ready to --

MEMBER BONACA: One question I have, I think one important element in the timing of inspection would be in my judgment how long has it been since a utility has done volumetric inspection of its own pressurizer flaws? I mean, are you considering that?

MR. MARION: Yes.

MEMBER BONACA: Okay.

MR. MARION: Yes. We've asked the utilities to look at the documentation they may have relative to the fabrication of the original welds as well as the results of inspections that were conducted previously. And we talked about a little bit during Ted Sullivan's presentation on the ten-year ISI.

As I mentioned before -- and I am going to go through these quickly because I want to try to --

MEMBER ABDEL-KHALIK: Excuse me. Would you, then, have a modified graph like the one you have on this previous slide that shows time between the planned inspection and the last inspection?

MR. MARION: We can provide that information. We'll make that a slide for the subcommittee meeting later this month if that's okay.

MR. ROBINSON: Alex, just a point along that line also. Part of the reason most are going straight to mitigation, as opposed to trying to do inspection, is simply because many configurations that currently exist in the plants are not inspectable.

The current PDI, you know, your protocol, we may have I'm sure also have done inspections, but the question remains how many have done? You have the PDI-qualified inspections, which is the rules we're playing by.

MEMBER MAYNARD: We didn't hang up on him.

CHAIRMAN SHACK: You are right. The conference lasts an hour, right.

MR. MARION: Okay. So I'll move on. Enhanced leakage monitoring. There are a couple of things in place. What the utilities had communicated to the NRC was their current enhanced leakage monitoring program.

Now, that program goes well beyond what's in the tech specs primarily because of lessons learned from the Davis-Besse experience. And I have a graphic that will speak to that in a little more detail.

Additionally, INPO was conducting review visits of the utility programs relative to managing degradation of primary system components. And one key aspect of that is an effective leakage monitoring program.

The data we have collected thus far for the 2007 and 2008 plants indicating that the utilities are taking action up to around .3 gpm, that's .3 gallons per minute unidentified leakage.

CHAIRMAN SHACK: But Davis-Besse was like .1 to .2, right?

MR. MARION: No. I think it was like .6. Wasn't that the average? I'm sure the NRC can speak to that at the meeting, the next meeting of the subcommittee.

The Westinghouse Owners' Group has developed some guidance on an enhanced leakage monitoring program. And that guidance is currently being evaluated by the Pressurized Water Reactor

Owners' Group. And they understand quite well what the NRC staff expectations are relative to the action levels, specifically taking shutdown action at certain thresholds.

The way our program is set up, we allow the issue programs the opportunity to determine what positions they want to take that become mandatory for all of the utilities that are affected by that particular program. That's something that's in play. And we expect that to be resolved within the next month or so. But that group is taking a serious look at these programs.

This represents the results of a quick and dirty survey we took based upon responses from 44 of the 69 plants. It gives you a range of the thresholds that they have in their programs to date.

When we refer to the baseline, each -- well, not each one, but there are different baselines that people are using based upon the current conditions or leak rates from the last inspection, et cetera. So it is a little bit of a variable. But these are the action thresholds, if you will. And we will hopefully have more data on this as we prepare for the subcommittee meeting on the 21st.

The real big issue between the industry

and the NRC is the fact that we think there is adequate time between leakage and failure of the pipe such that appropriate corrective action can be taken by the utility.

We did duplicate, if you will, for lack of a better term, -- and if I'm saying an incorrect term from an analyst's point of view, I expect to be corrected. We did duplicate the NRC analysis and came up with relatively similar conclusions.

But we feel that a more detailed analysis would be warranted. And we, quite frankly, believe that it may indicate that there is additional margin between leakage and rupture.

Now, the industry is prepared to deal with the results of this analysis. And if the results show there is additional margin, then that information will be provided to the NRC, but if the results show that nothing has changed from what we have already concluded, then the utilities will take appropriate action.

The point of doing this analysis is to make sure that we have the best information available to the utilities so they can make the best decision they possibly can as to whether or not they should continue with their current plans to do inspections in

2008 or possibly expedite those inspections by doing some in 2007.

I can tell you right now my own personal opinion, for what it's worth, I don't think all nine plans can do inspections in 2007. I don't believe we have the infrastructure. I don't believe the good conditions will allow it above and beyond what's currently planned for 2007, but that's a personal opinion at this point.

I don't know if Glenn wants to add anything relative to this non-linear finite element analysis. We just started the work. We had already indicated to the staff that as we go through this technical work, we will be engaging them and keeping them apprised of what assumptions we're making, what load conditions we're considering, et cetera.

And our objective is to try to get this analysis completed midsummer so that we can communicate the results to the utilities again so they can make an informed decision on what their actions ought to be going forward.

MEMBER ABDEL-KHALIK: I guess that my understanding is that the time period that the unidentified leak remains unidentified in tech spec is relatively short before the operator if the leak remains unidentified for a relatively short period of time, meaning a day or so, then the operator has to take some action.

So that time period seems to be significantly shorter than the accuracy of any modeling that you come up with. So I am not sure what are you gaining by sort of sharpening your pencils as far as the models are concerned?

MR. WHITE: The main question at issue is whether you're going to have a through-wall flaw that can leak at all before there is a rupture of the weld. If one has a large enough crack that does not penetrate through the entire thickness, that could still cause a rupture directly with no opportunity at all for detection of leakage.

MR. ROBINSON: This again is Mike. But I think it's important to point out if you look back up on slide 8, there's a reference to a Palisades and a Tsaruga 2 event. And both of those are in these small bore lines that we're talking about.

And what the experience there showed us is we had small leaks that were identified on plant instrumentation and plant walk-downs. And these are the same lines that we're talking about. There's essentially being a very small increment of time between leakage and pipe failure.

So here are two clear examples where that is not the case.

MR. WHITE: I would add a few comments to follow up on Alex. The program that we are in now Alex mentioned we just started. It's a five-month program, but within the first month, we will have results. The whole five-month period is to allow time for reaching consensus on assumptions to look at sensitivity cases, to look closely at the conditions for the nine plants that are most at issue that are planning to do mitigation in Spring of '08.

So it's a program that is intended to bring in experts within the industry on the NRC side, outside the industry together to look towards bounding calculations and towards consensus. It's not intended to be another scoping calculation.

MEMBER ARMIJO: Exactly what is this analysis is expected to change, for example, the geometry of the growing track?

MR. WHITE: There are two main things that we are looking at. The first item is the shape of the crack. Previous calculations have assumed it stays as a semi-ellipse and driven by crack growth at the deepest point and the surface point, which were assumed to have relatively high stresses in comparison to the stresses at other points along the crack front.

So, in reality, the crack shape is going to change. And preliminary work indicates it can be a significantly smaller cross-sectional area of that crack when it reaches through-wall penetration versus this semi-ellipse assumption. So it's a technical assumption.

CHAIRMAN SHACK: But how are you going to handle the range of residual stresses that you --

MR. WHITE: That's the second part that we're looking at. That is to a multi-prong approach. We have done many calculations simulating welding residual stress in the past. We're going to build on that to look specifically at these nine plants at issue.

On top of that, we're going to look at more sensitivity cases and then use that as the basis for sensitivity cases, different magnitude, residual stresses, different profiles through the wall, different profiles around their circumference, and to look at enough cases to build consensus that we have sufficient assurance about how these cracks should grow.

CHAIRMAN SHACK: I can understand you

getting probablistic results. I have a hard time believing you'll get a bounding result that you can live with.

MR. WHITE: Well, we want to have sufficient confidence in our result in order to --

CHAIRMAN SHACK: It will be interesting.

MR. MARION: Okay. In conclusion, we fully understand NRC concerns with regard to recent inspection results and their basis for extending those concerns to the remainder of the fleet. But we fundamentally think that the NRC's position is extremely conservative.

I talked about the letters that utilities have submitted to the NRC. So the NRC now has docketed commitments, if you will, of what the plans are for those utilities to conduct inspection mitigation in 2007 and 2008.

As I mentioned before, the program we have laid out in MRP-139 we continue to believe is valid, reasonable, and is responsive to our understanding of this important degradation mechanism.

And, lastly, we believe that the plants are still in a position where they can continue to operate safely until the next refueling outage when the inspection and mitigation activity is completed.

And that concludes my presentation. I would like to speak to the one question that was raised about opportunities to conduct destructive examination of the Wolf Creek.

We have had some discussions with the management of Wolf Creek along those lines. And the discussions are still in play. I am not at liberty to suggest any conclusion.

I think Wolf Creek's next rescheduled outage is the Fall of 2008 if my memory serves me right. And, as we progress, once a decision is made relative to what Wolf Creek may do or may not do, we will be more than happy to communicate that with this Committee and the NRC staff. The decision at this point rests with Wolf Creek management.

Okay. That completes my presentation. I will be more than happy to answer any --

MEMBER MAYNARD: One other thing I think needs to be factored into this if we look at accelerating schedules is there are limited resources that can do a quality job in both the inspection and especially in the mitigation of these.

And I think we need to be careful we don't overstretch the resources. I think it's important to get these things mitigated correctly, rather than just toss a whole bunch of money or something.

MR. MARION: I would just add, speak to Mr. Maynard's comments. We have spoken with key vendors who support these inspections. One can always conclude that you could squeeze another inspection or mitigation activity in in the middle of summer, but the question is whether you can implement that outage in the middle of the summer, when you need the electricity. And so that's one of the --

MR. ROBINSON: This is Mike. What we're talking about, to do a typical overlay of these nozzles on a pressurizer, you're talking about a minimum of roughly 30 days from the time you shut the plant down, get it into a condition where you can do the overlay, perform the overlay, perform the work, demode the area, and then put the unit backbone, you're talking about roughly a good 30-day period. And that assumes you don't have any rework or other issues that you encounter as you're going through the project itself.

MR. RILEY: There's a myriad of other considerations that come to play here. The dose considerations are one. You can fit so many of these in based on the resources of being able to do the overlay. But these overlays actually hold quite a bit of dose. And the people who are the folks who do the overlay are --

MEMBER ARMIJO: Plant to plant.

MR. RILEY: -- limited from that perspective. And it can be pretty significant. Another thing that --

MEMBER ARMIJO: I just want to make clear basically everybody who is doing the inspection is going to be prepared or plan to do an overlay anyway.

MR. MARION: The majority of utilities are planning to do overlays. There are only two that we're aware of who are planning to do inspections. And those are going to be conducted this year, in 2007.

MEMBER ARMIJO: So they go in. They do an inspection hoping or anticipating there would be no findings of concern.

MR. ROBINSON: I think what you would find is that the smart way to plan these if you just plan to do the inspection is you do have a contingency to bring in a vendor should your inspection results find something. So I don't think anybody would plan to do an inspection without having a pretty well-thought-out and planned overlay as a backup.

MEMBER ARMIJO: That's what I expected.

I just want to make sure.

MEMBER MAYNARD: I know at Wolf Creek, the original plan had been to inspect and have a contingency plan. Actually, the cost of having resources standing by turned out to be about as much as going ahead and planning the mitigation. So I believe they made the decision to go straight to mitigation because it didn't cost that much more.

MEMBER ARMIJO: Okay. If there aren't any other questions, Mr. Chairman, it's all yours.

CHAIRMAN SHACK: Thank you very much for a good presentation. Let's see where we're at. It's back to you, Otto, for our work on the reg guides and SRP sections, our favorite topic.

MEMBER MAYNARD: Our favorite topic here. I'm sorry. Do we need the recorder?

CHAIRMAN SHACK: We don't need the recorder any more this afternoon.

(Whereupon, the foregoing matter was concluded at 2:19 p.m.)