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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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584TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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OPEN SESSION

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WEDNESDAY

JUNE 8, 2011

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ROCKVILLE, MARYLAND

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The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 8:30 a.m., Said Abdel-Khalik, Chairman, presiding.

COMMITTEE MEMBERS:

SAID ABDEL-KHALIK, Chairman

J. SAM ARMIJO, Vice Chairman

JOHN W. STETKAR, Member-at-Large

SANJOY BANERJEE, Member

DENNIS C. BLEY, Member

MICHAEL L. CORRADINI, Member

DANA A. POWERS, Member

HAROLD B. RAY, Member

MICHAEL T. RYAN, Member

WILLIAM J. SHACK, Member

JOHN D. SIEBER, Member

NRC STAFF PRESENT:

CHRISTOPHER BROWN, Designated Federal Official

JOHN LAI, Designated Federal Official

PETER WEN, Designated Federal Official

RAJENDER AULUCK, NRR/DLR/RASB

ERIC BOWMAN, NRR/DPR

BENNETT BRADY, NRR/DLR/RPB1

DOUG COE, RES

RICHARD CONTE, R-I/DRS/EB1

RICHARD CORREIA, RES

ARTHUR CUNANAN, NRR

PAUL CLIFFORD, NRR

CLIFF DOUTT, NRR/DLR

MICHELLE FLANAGAN, RES

MELANIE GALLOWAY, NRR/DLR

KATHY GIBSON, RES

EDWIN M. HACKETT, ACRS Executive Director

ALLEN HISER, NRR/DLR

BRIAN HOLIAN, NRR/DLR

DAN HUDSON, RES/DRA
THOMAS KOSHY, RES/DE
RALPH LANDRY, NRO
ROY MATHEW, NRR/DE
BO PHAM, NRR/DLR/RPB1
STACEY ROSENBERG, NRR/DPR
HAROLD SCOTT, RES
ABDUL SHEIKH, NRR/DLR/RASB
MARTY STUTZKE, RES/DRA

ALSO PRESENT:

MIKE BILLONE, Argonne National Laboratory*
ROBERT C. BRAUN, PSEG Nuclear LLC
PAUL DAVISON, PSEG Nuclear LLC
JOHN HILDITCH, Exelon
RALPH MEYER, Argonne National Laboratory*
JOHN F. PERRY, PSEG Nuclear LLC
GEORGE SEIBOLD, PSEG Nuclear LLC
JAMES STAVELY, PSEG Nuclear LLC
KEN YUEH, EPRI

*Present via telephone

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

P R O C E E D I N G S

8:29 a.m.

CHAIRMAN ABDEL-KHALIK: The meeting will now come to order. This is the first day of the 584th Meeting of the Advisory Committee on Reactor Safeguards. During today's meeting, the Committee will consider the following:

(1) Draft Regulatory Guide DG-1261, Conducting Periodic Testing for Breakaway Oxidation Behavior; DG-1262, Testing for Postquench Ductility; and DG-1263, Establishing Analytical Limits for Zirconium-Based Alloy Cladding;

(2) Revised Safety Evaluation Report Associated with the License Renewal Application for the Hope Creek Generating Station;

(3) Commission Paper on Level Probabilistic Risk Assessment Activities;

(4) NRC Bulletin 2011-01, Mitigating Strategies; and

(5) Preparation of ACRS Reports.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Mr. Christopher Brown is the Designated Federal Official for the initial portion of the meeting.

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

There will be a phone bridge line. To preclude interruption of the meeting, the phone will be placed in listen only mode during the presentations and committee discussions.

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

We will now proceed to the first item on the agenda, Draft Reg. Guides 1261, 1262, 1263. And Dr. Armijo will lead us through that discussion.

MEMBER ARMIJO: Thank you, Mr. Chairman.

The purpose of the briefing this morning is to receive an update on the rulemaking activities and on three draft regulatory guides related to revision of 10 CFR 50.46(b). This material was reviewed on May 2011 in a subcommittee meeting. And today we're going to hear presentations from the Office of Nuclear Reactor Regulation and Nuclear Regulatory Research as well as a presentation by the Electric Power Research Institute. We'll also have

Mike Billone of Argonne National Laboratory and Ralph Meyer on the bridge line and there may be other people on the bridge line.

Just to refresh the Committee's memory of the conclusions and recommendations of our letter that the ACRS wrote in December of 2008, the three points that we raised and which will be addressed in these presentations:

(1) our conclusion and recommendation was that there are sufficient data and understanding of the cladding embrittlement phenomena to justify and proceed with rulemaking;

(2) the rule should include the proposed optional testing program to allow licensees to demonstrate compliance with postquench ductility criteria on a alloy-specific and temperature-specific basis;

(3) a round-robin test program would be beneficial in the validation of the test procedures used to demonstrate compliance with postquench ductility and breakaway oxidation criteria.

With that, I'll just turn over the briefing to Paul Clifford of NRR to start.

Paul.

MR. CLIFFORD: Good morning. Thank you.

Two and a half years ago the staff briefed this Committee on the high burn-up LOCA research program findings and a rulemaking strategy for incorporating these findings into a revision to 10 CFR 50.46. During that briefing, the concept of replacing the existing prescriptive criteria with performance-based requirements was introduced. As part of that approach, DTO regulatory guidance documents were needed to provide an acceptable means to meet the performance-based requirements that would be in the rule.

The staff has completed these three reg. guides. And the purpose of today's meeting is to go through these regulatory guidance documents and obtain ACRS's concurrence to issue them in draft form for public comment. So I'll begin by going through the agenda really quickly.

I will be providing a brief summary of the 50.46(b) rulemaking project with respect to past, present and future ACRS interactions. I will be followed by Michelle Flanagan from the Office of Research who will be presenting an overview of these three draft reg. guides and describing how this guidance supports the performance-based requirements within the draft proposal language. Later, the industry will present results from their on-going local research program and will introduce a round-robing type exercise at several labs.

This slide which outlines the rulemaking objective was presented at the last full Committee in December of 2008. These rulemaking objectives have not changed. Following Commission directive, a performance-based rule has been developed and, as a result, the applicability of the proposed rule goes well beyond just zircaloy and ZIRLO. Further, the proposed rule captures the results of the high burn-up LOCA research program.

During past ACRS interactions, the findings of the research program were presented. These findings demonstrate that the existing prescriptive criteria of 2200° Fahrenheit and 17 percent ECR do not necessarily achieve the underlying objective of the rule which is to maintain postquench cladding ductility.

The research identified new embrittlement mechanisms including hydrogen-enhanced prior-beta layer embrittlement, cladding ID oxygen ingress and breakaway oxidation. During past briefings, the staff outlined the scope of the proposed rule including the development of performance-based rule to capture these research findings.

At the time, the staff was considering specific numeric criteria within the rule language itself along with an optional test program. Future reg. guides would be developed to provide the guidance for performing the optional testing program. The staff was also considering issue in ANPR to solicit public stakeholder input on specific topics.

That was in the past. A letter was issued in December and Dr. Armijo has already gone through the three conclusions and recommendations within that. So I will not repeat that.

Since our last interaction, the ANPR was developed and issued. Comments were received from several utilities, each of the three fuel vendors, international research and regulatory agencies as well as members of the general public. All the comments will be documented and the staff's response to those comments will be provided in the proposed draft rule package.

In addition, the Office of Research has completed additional postquench ductility and breakaway testing. This includes testing of irradiated cladding segments of ZIRLO at intermediate hydrogen levels and also an investigation into the effects of transient temperature profiles on the timing of breakaway oxidation.

The proposed rule package was revised removing the specific numeric requirements within the rule itself such as the one percent plastic strain. And those have been moved to the associated regulatory guidance documents.

And lastly as I mentioned the three draft reg. guides have been developed and that's the focus of today's discussion.

MEMBER ARMIJO: Paul.

MR. CLIFFORD: Yes.

MEMBER ARMIJO: You know, the strain being a requirement in a reg. guide, is that really appropriate? We say it would be acceptable. I'm getting a little -- I always understood requirements had to be in the rule.

MR. CLIFFORD: Yes.

MEMBER ARMIJO: In the regulation. So I didn't understand that move.

MR. CLIFFORD: Well, the performance-based objective of the rule here is to ensure cladding ductility. Now there are many ways of measuring cladding ductility.

MEMBER ARMIJO: Okay.

MR. CLIFFORD: We could codify the one percent plastic strain as the means. Or we could just identify within the rule that you need to maintain ductility.

MEMBER ARMIJO: And that's the language.

MR. CLIFFORD: And then the reg. guide would then provide one acceptable means of measuring ductility.

MEMBER ARMIJO: Okay. Thanks.

MR. CLIFFORD: This removing it from the rule language and putting it in the reg. guide provides more flexibility for each of the labs or improvements in laboratory techniques.

MEMBER ARMIJO: Okay.

MR. CLIFFORD: This slide identifies some new items which have not been previously discussed with the ACRS. First is the staff has developed a draft generic letter to obtain plant-specific information to confirm plant safety recognizing that the implementation of a new rule would take several years. In response, the industry has --

MEMBER POWERS: Where are the steps that lead you to say it will take several years to implement? I mean you can put the new rule in and it's instantly there --

MR. CLIFFORD: Right.

MEMBER POWERS: -- with the stroke of a pen. But you said implement and I wonder what you meant by implement.

MR. CLIFFORD: The implementation of the new requirements would require the fuel vendors to develop new models and then those models would then have to be rolled across 103 different reactors. And we recognize that a LOCA analysis is very timely to complete and that it would take several years for the fuel vendors to perform all of those analyses for each of the reactors and for the NRC to review those analyses.

MEMBER POWERS: It is the performance of the analysis that you think is the time.

MR. CLIFFORD: Yes.

MEMBER POWERS: The models themselves, their development is done?

MR. CLIFFORD: No. The fuel vendors can't validate their new models unless they're sure what the rule is going to require. So essentially it's done in series. Once the rule is finalized, then the requirements are known and then the models would need to be updated. And the ECCS performance demonstration need to be done for each of the reactors. And then the NRC would need to review those.

MEMBER POWERS: I think I'm struggling with how long it takes to do that middle step. The models get updated and then they get validated. And what is the timing on that?

MR. CLIFFORD: We've done a detailed implementation plan whereby we're trying to -- well, recognizing that there's only limited resources both in the industry and in the staff to review all of this work. We've developed a stage implementation. This will all be documented in the proposed rule package which this Committee will review later this year or early next year.

But essentially once the rule is accepted by the Commission, the final rule, then the models will be updated and new models would need to be developed. And then we've staged the implementation into three tracts and the tracts would be set based upon the amount of available margin. In other words, the plants with the least available margin would be implemented -- would implement the new requirements first and so on and so forth.

MEMBER ARMIJO: Least available margin vis à vis the current requirements?

MR. CLIFFORD: No. The new requirement.

MEMBER ARMIJO: So what is -- How would you know that ahead of time?

MR. CLIFFORD: The industry has just completed a significant effort whereby they've quantified the margin for each and every reactor and they've provided that information. So we can use that information on a plant-specific basis to assign plants in the different implementation schedules.

CHAIRMAN ABDEL-KHALIK: Now we haven't seen that assessment yet.

MR. CLIFFORD: It just arrived last week and we are setting up an audit plan right now whereby we'll go to each of the field vendors and audit all of the underlying engineering calculations to ensure that all the information that we need to ensure plant safety has been provided.

MEMBER ARMIJO: Okay. Go ahead, Paul.

MR. CLIFFORD: Second, the Office of Research has completed integral LOCA testing on un-irradiated and irradiated fuel rod segments to investigate the mechanical properties of the fuel rod burst region. During a LOCA, many of fuel rods are predicted to experience fuel rod ballooning and burst due to elevated cladding temperatures in combination with an increasing delta pressure across the cladding wall due to the RCS depressurization. The performance of the small burst region was largely outside the scope of the original Argonne LOCA research program.

Third item is the Office of Research is investigating fuel pellet fragmentation and dispersion under LOCA conditions. All available integral LOCA test data from various domestic and international research programs has been compiled. And the staff is using this database to decide whether to expand the scope of the rulemaking to include new regulatory requirements to address this phenomena.

Each of these items will be the subject of a future ACRS briefing.

This slide identifies future interactions with the Subcommittee and the full Committee. Today we are talking about the draft regulatory guides documents. The expanded technical basis will be discussed in two weeks with the Subcommittee. Right now, I don't believe there's a schedule for the full Committee.

MEMBER POWERS: Can you come back to the previous slide where you've got something --

MR. CLIFFORD: Absolutely.

MEMBER POWERS: Under Item 3, you concerned the expansion of the rulemaking scope to include fuel fragmentation and dispersion.

MR. CLIFFORD: Yes.

MEMBER POWERS: Tell me what that means.

MR. CLIFFORD: Okay.

MEMBER POWERS: Why are we doing that?

MR. CLIFFORD: We've identified recent tests that Halden have further shown that fuel pellets can fragment under LOCA conditions. And this fragmentation can be of a size whereby the fuel can be expelled out of the fuel rod during the bursting of the fuel rod.

MEMBER POWERS: None of this is exactly earth-shaking news.

MR. CLIFFORD: Correct.

MEMBER POWERS: I mean we have known that the pellets can fragment. We know that they can disperse. I mean, Dick Lorenz showed that in a burst test back in the '70s.

MR. CLIFFORD: Correct. But the underlying objective of 50.46 is to ensure that the fuel rods are maintained in their coolable bunch array because that's something that can easily be modeled. If a significant portion of the fuel rods balloon and burst and a significant portion of the fuel pellets within those fuel rods are expelled in the RCS then that's not achieving the underlying objective of the rule which is to show that the core remains coolable and to maintain the rods in their bundled array. I mean the rods will still be in the bundled array, but portions of the fuel pellets will be expelled out the burst opening. And that's a phenomena that's not currently tracked.

We originally -- One of our earlier positions was that the size of the fragments is a function of burn-up and that some of the earlier Halden data showed that very, very high burn-up fuel well beyond our current license limit. The fuel would fragment into very small particles and these particles would be expelled into the test chamber. But those rods were at 86-90 gigawatt days.

We've recently seen fuel rods at burn-ups approaching or right at our license burn-up limit of 62 which is showing a similar phenomena. This is something that we feel that the Commission should be informed about.

MEMBER POWERS: Without going into the quantitative nature of this which is really important in this particular observation, are you proposing in this third item that to arrest this new rule until you understand this?

MR. CLIFFORD: We haven't made that decision. One option would be --

MEMBER POWERS: I mean we have written at least twice that I know of that this work has gotten far enough that we ought to incorporate it into the regulations because it's a significant finding that affects the plants within the current burn-up limits.

MR. CLIFFORD: Correct.

MEMBER POWERS: And it should get into the requirements and to continue to find little things that we don't understand to delay this process is not helping that.

MR. CLIFFORD: We agree 100 percent. And our plan right now is to complete the rulemaking package based upon what we were told to do and what we said we were going to do which is to incorporate existing technical basis into performance-based rule requirements, develop a proposed package and get that to the Commission. We plan on doing that and we're going to do that on the advertised schedule.

But as part of that package we may just develop a basis for addressing this new phenomena and just provide that to the Commission as "Here is another phenomena that's not covered by this rule package." And that would give them the option of deciding whether to go forward with the package as is or whether to delay the package to address this additional phenomena. But the package will be complete and it will be ready to be sent out and drafted.

MEMBER ARMIJO: So this would be supplemental information provided with the rule but not included in the rule.

MR. CLIFFORD: Correct.

MEMBER ARMIJO: Okay. That says "Hey, look. We've covered all of this stuff, but there are a couple of other observations and we're thinking about it." Or you make some specific recommendations.

MR. CLIFFORD: Correct.

MEMBER ARMIJO: You haven't decided whether you'll recommend that the rule be held up to incorporate these new findings.

MR. CLIFFORD: We haven't made that decision.

MEMBER ARMIJO: Okay.

MR. CLIFFORD: But the rule package will be complete and it will encompass all of the existing research and the performance-based objectives of the rule. So the package will be complete and ready to go out. It's almost -- You can kind of consider we're using the vehicle of the SECY letter associated with the rulemaking as a vehicle to inform the Commission of this new phenomena because it is tied in with LOCA.

MEMBER ARMIJO: Okay. Go ahead, Paul.

MR. CLIFFORD: Okay. So today we're talking about the draft reg. guides. I think it's important to realize that this Committee will have the option of reviewing these reg. guides again after they go out for public comment and we've addressed those public comments before the documents become final.

As I mentioned, in two weeks we're going to be talking about the expanded technical basis which is the mechanical behavior of the burst region. And then the proposed package will be completed this fall. The Subcommittee will get it in December. I believe the full Committee will get the briefing on the proposed rule package in February.

After that, it goes up to the EDO. The date for delivery to the EDO is the end of February 2012. And then after the Commission decides to go out for public comments, we intend to final the rule in 2013.

CHAIRMAN ABDEL-KHALIK: The expanded technical basis meeting, do you mean the study that was performed by industry to quantify the margin for various plants or when would that be -- When would we be given the opportunity to review that?

MR. CLIFFORD: The staff intends to use the plant-specific information provided by the industry to complete a safety assessment and that safety assessment will be part of the proposed rule package. In other words, you'll say "Here's the implementation plan. It's going to take several years. Here's why it's okay that it's going to take several years. Here's a plant-by-plant assessment of safety margin." So that would be referred to in the proposal package.

CHAIRMAN ABDEL-KHALIK: So the earliest that we can take a look at that would be in December of this year.

MR. CLIFFORD: Correct.

MEMBER ARMIJO: Now if that information --

MR. CLIFFORD: It will be completed before then, but it won't be presented to you before then.

MEMBER ARMIJO: Right.

MR. CLIFFORD: As of right now it's not on the schedule.

MEMBER ARMIJO: Right. But in the event that that information that's been provided to you is not adequate you have in your back pocket this generic letter issue.

MR. CLIFFORD: Correct.

MEMBER ARMIJO: And you probably have to fill us in on what the strategy is on that and whether it will ever be issued. And if it is going to be issued, will we get to see it?

MR. CLIFFORD: Correct. After we perform the audits of each of the vendor calculations and collect all the necessary data, we'll make a decision whether or not to proceed with the generic letter. Generic letter has been drafted. The generic letter has been approved by the CRGR. And right now the plan is to issue the generic letter as draft for public comment.

MEMBER ARMIJO: Okay. And we'll see that after public comment or what?

MR. CLIFFORD: Yes, I don't think the --

MR. BROWN: It's part of your package, the notebook.

MEMBER ARMIJO: Pardon?

MR. BROWN: I put the generic letter as part of the notebook.

MR. CLIFFORD: I don't believe the procedure is that the ACRS reviews the generic letter in draft form.

MEMBER ARMIJO: I don't know either, but maybe some of the more senior members --

MR. HACKETT: Maybe I can help clarify. Ed Hackett, ACRS. The normal process for review of generic letters when they are going to go final would include ACRS and CRGR review unless the EDO decides it needs to go out more expeditiously like what has happened with the bulletin we'll be reviewing today. So the Committee would be afforded an opportunity to review that.

MEMBER ARMIJO: In final form.

MR. HACKETT: In final form, right.

MEMBER ARMIJO: Okay. Well, that's still an option and we don't have it on our schedule at this point.

MR. CLIFFORD: Okay. And on my last slide, I'll just reiterate that the objective here is to obtain concurrence to issue the draft reg. guide for public comment and also to provide the industry an opportunity to brief ACRS on its ongoing LOCA research program and its planned round-robin exercise. And that's my last slide.

MEMBER ARMIJO: Okay. Thank you, Paul.

Any questions?

Michelle, you're on.

(Off the record comments.)

MS. FLANAGAN: Thank you. My name is Michelle Flanagan. I work in the Division of Systems Analysis in the Office of Research. And as Paul said I'm going to be presenting an overview of three regulatory guides that have been developed in support of emergency core coolant system rulemaking.

And also Paul presented, the objective of this meeting is to present the background, the context and details of three regulatory guides that are supporting ECCS rulemaking. And I'm not going to go through all of this again because this was also part of Paul's presentation. But how we got here is fuel cladding research program that investigated the behavior of high-exposure fuel cladding under accident conditions. And there are findings associated with this research program that we wanted to incorporate into rulemaking, specifically hydrogen-enhanced embrittlement, breakaway oxidation and oxidation from the inner cladding diameter that was due to fuel cladding bonding that had an impact on embrittlement.

So rulemaking was an issue then to revise the ECCS criteria. And in that activity the revisions were intended to develop performance-based features. So what the rule language calls for is material-specific analytical limits that account for the material-specific burn-up effects. It calls for ECCS performance to be consistent with avoiding measured breakaway behavior, one of the phenomena that was identified in the research program. And it also calls for periodic testing of breakaway oxidation behavior.

The approach to implement a performance-based rule that we're proposing here is to use regulatory guides to provide a means of consistent, comparable data generation, to establish regulatory limits on peak cladding temperature and oxidation and to use regulatory guides to provide a means of consistent, comparable data generation to establish and periodically confirm regulatory limits related to breakaway oxidation and to provide a consistent means of using experimental data developed through these first two test programs in order to actually establish regulatory limits and, in doing so, simplifying the review process and reducing regulatory uncertainty and minimizing the costs associated with the implementation of a performance-based rule. Specifically, three regulatory guides were developed.

The first one, Draft Guide 1261, is a test procedure for measuring breakaway oxidation behavior and for periodically confirming consistent behavior.

Draft Guide 1262 is a test procedure for measuring postquench ductility using ring compression tests. And then the third reg. guide is a guidance for developing analytical limits from data. And in this case the data would be generated through the test procedures that are presented or that are available in the draft guides 1261 and 1262. That's not a requirement, but that's an option.

So here we've developed these draft reg. guides and we're about to go out or we're pursuing stakeholder interaction and public comment. And what we'd like to do and gain from that stakeholder interaction-public comment is assurance that the details and the expectations of acceptable methods for measuring properties of zirconium-based alloys are communicated effectively and completely. We also want to ensure that measured breakaway behaviors are expected to be repeatable within a laboratory and between laboratory. And we also want to ensure that analytical limits can be developed consistently across fuel designs.

These regulatory guides were developed in a relationship to our rule language. And so here I'm presenting the proposed draft rule language to indicate how we get to pointing out to regulatory guides. I'm not going to read all of it, but in this one that deals with breakaway behavior it says, the proposed language would say that an acceptable experimental technique should be used to measure breakaway behavior and that the objective of this or the requirement of the rule is that a specified and acceptable limit is developed that sets a maximum for behavior. And so ECCS performance ensures that the susceptibility to this phenomenon is not greater than this specified and acceptable limit.

The first regulatory guide that I had mentioned, 1261, is an acceptable experimental technique for measuring breakaway oxidation behavior. And then draft guide 1263 provides a method for using the data that you generate using that regulatory guide or another method of that is pursued. It actually sets a specified and acceptable limit. Really defines our requirements and expectations for how an analytical limit should be supported.

And then the proposed draft rule language for peak cladding temperature and oxidation has the same format where we say an acceptable experimental technique shall be used to measure a ductile-to-brittle transition for zirconium alloy-based materials and that a specified and acceptable limit should be developed for peak cladding temperature and time at elevated temperature. So again we have the two regulatory guides that define our requirements for this, the first 1262 defining a test procedure and an acceptable experimental technique and then 1263 again explaining our expectations for how to use data to support analytical limits.

The next couple slides are really in response to some questions that we want to provide some further discussion of. And it's about acceptable experimental techniques. Because in here we've specified or we're offering in this draft regulatory guide an acceptable experimental technique and it is a ring compression test.

And so we want to emphasize that that provides a certain -- To be that specific about an experimental technique provides a way that -- it provides regulatory stability and regulatory certainty. It is not the only way. We're not specifying that it is the only technique that can be used to measure the ductile-to-brittle transition.

We really wanted the rule language to reflect flexibility and any experimental technique could be submitted for NRC review and approval. Or the regulatory guide that we're proposing would be a readily available experimental technique that would be considered already reviewed and approved by NRC. And this technique, as I said, does use ring compression tests.

And other methods could be used. And other methods have been shown to yield comparable results. Particularly three point bend tests are something that in the literature there have been comments about the comparability of ring compression tests and three point bend tests.

And I want to say that none of the programs that we're referencing here were specifically designed to prove the comparability of three point bend tests and ring compression tests. However, they do have -- Basically, they were designed to prove other objectives.

But within the dataset there is the ability to make comparisons between the two testing approaches. And then the conclusions that were documented in CEA's research, for example, are to note that the conclusions of where the ductile-to-brittle transition takes place are markedly consistent between the two tests.

MEMBER ARMIJO: I'd like to expand a little bit. I asked the staff to expand in this area because we're relying on the ring compression test as the fundamental method that everybody is working on, the industry as well as the staff and Argonne.

And I wanted to be sure that -- Well, since the loading of a fuel cladding during the quench is either bending or tension, possibly even compression, that's very different than the loading that we put on bi-ring compression tests. And if the ring compression test is conservative, that's okay. It measures ductility and it's conservative. But if it turns out that it's not conservative that would be a problem and, other tests, the three point bending also measures ductility. And what we're really after is a material property of ductility.

I wanted to be sure that we didn't have any doubt that the ring compression test is a good method for demonstrating ductility. And it provides something we can have confidence in even if the loading is in a different orientation. And so I asked the staff to -- I did review the paper by Bracket and other people including I think Mike Billone is one of the co-authors. And I could not see that from -- They had some figures that were very difficult to read. So I asked them to expand that and provide the Committee that information so that we put this issue to bed that we're measuring fundamental property and the ductilities whether measured by ring compression or three point bend tests are equivalent. And that was my hope.

MS. FLANAGAN: Yes.

MEMBER ARMIJO: And I haven't seen the data yet.

MS. FLANAGAN: Okay. So I'll go onto those curves. And what I want to say is that what we're suggesting is that the two test methods measure brittleness in a similar way. And ductility is actually a little bit different. Because in a highly ductile material you may get differences in test methods in the actual offset strain, the absolute value of the strain before failure.

And what we're saying is that we're measuring the point at which the cladding becomes brittle. And in a wider range of techniques you'll identify that at the same conditions. The same amount of oxidation will yield a brittle result. I don't know if that --

Here's another thing I'll say. So there were two papers that were sent as supplements after the Subcommittee meeting. One is based on data that was generated -- Let me just make sure this is --

Okay. One is a more recent paper and one is an older paper.

And so, in the more recent paper, there was a large amount of data and CEA did an extensive test matrix and looked at a number of conditions. They looked at the quench temperature, oxidation temperature and hydrogen effects.

When we looked at the data and were trying to distinguish that which was directly relevant to what our test program is proposing, there's only a smaller subset that really is comparable. So in this chart what we're showing is data that was quenched from the same temperature as the test procedure suggests.

CHAIRMAN ABDEL-KHALIK: What are the numbers in this table?

MS. FLANAGAN: They are offset strain values.

CHAIRMAN ABDEL-KHALIK: Okay.

MEMBER ARMIJO: Percent strain.

CHAIRMAN ABDEL-KHALIK: Percent strain.

MS. FLANAGAN: Percent strain, yes. I'm sorry about that. That was oversight on my part to label that.

And one thing that I want to point out

about this data is that it was recalculated from the paper. The three point bend measurement in the paper were normal -- I don't know how detailed I want to get into this. But they're normalized to the diameter of the sample. And that's appropriate in the ring compression tests.

However, in the three point bend tests, there's a different thing that's being measured when you look at the deflection of the test. So you take a low displacement curve and you interpret something about it. And then you calculate the strain that is experienced. So in this table the three point bend strain values were recalculated based on a different approach to translating a low displacement curve to a strain value.

CHAIRMAN ABDEL-KHALIK: And you think that the two methods that demonstrate ductile-to-brittle transition at strain values of 1.16 percent versus 0.15 percent are consistent.

MS. FLANAGAN: Yes. The demarcation of brittle behavior really happens around 1.0 percent. So everything that's around that value is considered to be brittle. And what the -- All of the data that was generated on the conditions that were relevant to the test procedures all happen to be brittle. This plot would be a lot more satisfying if we had a lot of ductile results and a lot of brittle results and we could identify the transition.

CHAIRMAN ABDEL-KHALIK: I'm just asking a question that pertains to the data that's shown in this table.

MS. FLANAGAN: Yes.

CHAIRMAN ABDEL-KHALIK: And if you'll look at the second flow you had one test method that says that this transition happens at 1.57 percent strain. And the other one says after doing the calculation to make sure that these numbers are apples to apples comparisons you get 0.15 percent.

MS. FLANAGAN: So what I'm saying is that all of the data for here would be identified as brittle around 1.0 percent and these are the actual measured values. This is not marking the transition. It's actually just reporting what was measured. And in this case they're all what we would consider relatively brittle.

MEMBER ARMIJO: This is what I was worried about. I was looking for something that simply showed that if our acceptance criteria is 1.0 percent strain as measured by the ring compression test is that conservative when you look at the actual loading that the fuel would be on and the three point bend test is closer to what loading. And I was hoping that the data would show that the ring compression test is conservatives. But in a couple of these things it is conservative. But others it's not.

In other words, that DEZ 2 slow cool would be an acceptable result. But in the three point bend test that's much strain.

MR. CLIFFORD: Well, I'm sure the Office of Research can expand upon this. But there's nothing to say that the criterion used to judge the ductile-to-brittle transition which in this case would be 1.0 percent plastic for ring compression is the correct transition point for three point bend test.

MEMBER ARMIJO: Maybe we'd better just table it because I was --

MR. CLIFFORD: -- in the reg. guide but we accept the 1.0 percent as the figure of merit to mark the ductile-to-brittle transition married with ring compression test. That's what we're saying in our reg. guide. If the industry was to come in and say, "I don't want to use that reg. guide. I'm going to come up with my own experimental technique using three point bending," then the onus would be on them to define what that transition point should be.

MEMBER ARMIJO: Right. But on the previous slide you're making a statement that ring compression testing and three point bend testing has been shown to yield comparable results. And that's the reasons for these questions.

MS. FLANAGAN: Yes. I do understand that and I think what we're going --

MR. CLIFFORD: I put her on the wrong tangent speaking from a regulatory perspective. She's speaking from scientific perspective.

MEMBER ARMIJO: Yes.

MS. FLANAGAN: But a good point to put in place because a lot of work was done to look at the transition point of what we call brittle and ductile and ring compression tests. And now we're taking data that wasn't generated by NRC and that we're trying to make conclusions from. We're trying to justify other people's conclusions and we're going to get stuck.

What we're saying is that in measuring -- So, if I got back to this, in ring compression tests we can measure a permanent strain and an offset strain if the test is done in a certain way. The offset strain we've shown to be related to the permanent strain with a certain correlation that is correlated to the oxidation. As the oxidation increases, the offset strain that we're calling ductile-to-brittle transition is actually increasing.

For example, on the 1.57 ring compression test results for that one, it's pretty much -- I wish I had the information, but I wasn't able to extract that from the CEA data. But that ECR level is high enough that the transition is happening above 1.0 percent. Where we're calling brittle results is above 1.0 percent because this is a measurement of a offset strain not a permanent strain.

All I can really say from this subset of data is that all of the results for both test methods were what we considered to be brittle.

MEMBER ARMIJO: I don't see if from the data, but I don't want to hold you up, Michelle. I just think that for the same level of hydrogen the three point bend test indicates brittle behavior. Yet at least two of the -- If the 1.0 percent strain is an acceptance limit for the ring compression test for the same specimen with the same hydrogen, that would be acceptable.

MEMBER SHACK: But this is for offset strains. So you really can't use that number that way.

MEMBER ARMIJO: Maybe that needs to be

worked on and we can discuss that later some more. But really we need to make sure that these tests give you conservative strains or measure the -- Just looking at the chart, I would guess that the three point bend test would say you would be brittle at less than 600 parts per million hydrogen.

MS. FLANAGAN: I want to put out another --

MEMBER ARMIJO: If you did it that way. You know, if you're looking for what hydrogen level does it go from ductile-to-brittle behavior, the three point bend test might give you a different result than the ring compression test and its three point bending is more like -- it's the kind of loading that it's more likely to happen in a real situation.

So that's the concern. And I think we really need to nail that down as this goes forward. But I'd like to leave that with the staff for a moment and you'll have a chance.

MR. YUEH: May I make a comment on this?

MEMBER ARMIJO: No, I would like Michelle to finish up her presentation.

MS. FLANAGAN: Okay.

MEMBER ARMIJO: Then you can comment later during your presentation.

MS. FLANAGAN: Okay. Another set of data from an earlier paper is plotted here which I'm not sure is going to provide much given where we're at. So I'm just going to skip this slide and we can go back.

MEMBER ARMIJO: Appreciate that.

MS. FLANAGAN: So my conclusion slide is really just to present the schedule for these regulatory guides. So right now the regulatory guides are in interoffice concurrence and they'll be issued for public comment at the same time as the rule. And then they'll follow the standard revision and review process.

Another thing that occurs to me to say is that in the draft regulatory guide we have an extensive amount of -- a large test matrix that is really required to define the ductile-to-brittle transition. There is repeat testing. There is testing through a range of oxidation levels with the objective to really identify the transition, not just one brittle result versus one ductile result.

MEMBER ARMIJO: One datapoint.

MS. FLANAGAN: So the regulatory guides are set up to be able to provide that type of repeatability and assurance that what we're measuring is actually accurate because there is some possibility for variability in the test. So the regulatory guides really require PB testing for that reason.

MEMBER ARMIJO: Yes. You don't rely on just one test.

MS. FLANAGAN: Right.

MEMBER ARMIJO: Okay.

MS. FLANAGAN: So that's the last slide I have.

MEMBER ARMIJO: And I think we're pretty --

MS. FLANAGAN: The rest of it is just back-up material and I have a lot of back-up material.

MEMBER ARMIJO: I noticed that.

MS. FLANAGAN: Right.

MEMBER ARMIJO: It's good to be prepared.

But any comments or questions from the Committee before we move on to the EPRI presentation?

MEMBER POWERS: Let me just make sure I understand these last two slides because I'm a bit confused here. What I saw in your plot which you didn't want to go through was that --

MS. FLANAGAN: I can.

MEMBER POWERS: -- looking on the face of this that you have fair, some, offset strain available to you to get up to about 200 parts per million by weight hydrogen. And then all the tests, ring compression, three point bend, show substantial reduction in the amount of offset strain that you can get.

MS. FLANAGAN: That is true. I do want to point out that some of the tests though, the green and the blue, the ECR was very low.

MEMBER POWERS: Yes, green and blue doesn't help me.

MS. FLANAGAN: Okay.

MEMBER POWERS: Those are the same colors to me.

MS. FLANAGAN: So the way that this thing is plotted is to show the shapes of comparable results. And so what you'd want to notice is whether the M5 at 6.0 percent ECR tested in ring compression was comparable to the M5 at 6.0 percent tested in three point bend tests. And then beyond that because the ECR is varying between the datasets we actually do expect some differences or results between those datasets.

Did that answer your question or did that just answer a totally different question?

MEMBER ARMIJO: The thing that, when I

first read the paper, I was trying to decipher from a figure these tiny, tiny little amounts of strain and we're measuring a very small strain. And that's why it's important that the tests be very reproducible but also that the tests reflect the properties of the material under the loading conditions that would be experienced during the tests.

MEMBER POWERS: The thing that I think I'm struggling with a little bit, Sam, is once we get down to these small strains I don't care. Small is small.

MEMBER ARMIJO: But if you're accepting -- If you say 200 parts per million hydrogen is acceptable using one test and another test says "No, that transition happens at 100," you've got to think that through.

MEMBER POWERS: Yes, I understand what you're saying there and the threshold. But it seems to me that there was a fair consensus among these data that are shown here at about 200 you've got little strain available to you.

MEMBER ARMIJO: But there are some materials that might be different. Right. We'll see. You know, I'm just saying right now it's a little confusing to me and I was looking for a simple, easy to say "Okay. This is a conservative test."

CHAIRMAN ABDEL-KHALIK: I guess I'm struggling with the four datapoints at 150 wppm hydrogen. I mean that just tells me that you can get whatever you want to get. You just keep testing until you get the results you want.

MS. FLANAGAN: If the material is ductile, you do have the ability -- If you're in a region where you're still in the ductile region, you can have wide variability in the offset saying that's measured.

MEMBER SIEBER: Yes.

MR. CLIFFORD: I guess you would expect it only 3.0 percent ECR. At 150 ppm you would have a very ductile material. That's what all of our tests have shown.

CHAIRMAN ABDEL-KHALIK: So how do you explain the bottom datapoint there?

MS. FLANAGAN: This is a good question. And we wanted to --

MR. CLIFFORD: That's one of the reasons why we have them run many tests and then not only just run four tests but they have to identify what they perceive as being the transition and then run tests just above and just below that transition to confirm that that is in fact the transition. You're only trying to target or you work down to what the transition is, not to measure how much ductility it is. I mean if there's 30 percent offset strain or 10 percent offset strain they're both ductile.

CHAIRMAN ABDEL-KHALIK: But if you look at this and this is the test that you're specifying as acceptable in your reg. guide, does this make sense?

MS. FLANAGAN: Well, one thing that we're struggling with here is that this is not our data. There may be things within this dataset that we aren't aware of. So we're presenting and responding to a question that came up about --

CHAIRMAN ABDEL-KHALIK: But this data is informing your decision.

MR. CLIFFORD: No.

MS. FLANAGAN: Not really.

CHAIRMAN ABDEL-KHALIK: It is not informing your decision.

MR. CLIFFORD: No.

CHAIRMAN ABDEL-KHALIK: So what -- How is your decision informed then as to the suitability of that particular test?

MR. CLIFFORD: Do you have a plot that shows all the data that was used to draw the line?

MS. FLANAGAN: Not in this.

MEMBER ARMIJO: She has some back-up

charts but I think they're examples. They're not the actual --

MS. FLANAGAN: Yes. I know which one Paul is talking about. I don't have it in this presentation.

MR. CLIFFORD: Yes. If you could see all the data that was used to define what the ductile-to-brittle transition is as a function of hydrogen and how we drew the line it would be obvious that there is a lot of points just above and just below.

You're not trying to run cases to measure 20 percent offset strain. If you ran that case, you'd be -- If you ran that and got 20 percent offset strain, the first thing you would do is run another case except that instead of 3.0 percent ECR you'd go to 20 percent ECR. And you would see if that worked and you would keep honing in on how much can I push ECR for a given hydrogen until I reached that transition.

CHAIRMAN ABDEL-KHALIK: But if you're unlucky and the first experiment you run was that bottom datapoint amongst the four what would you do then?

MR. CLIFFORD: Well, the procedure would have you still run. You would still push it until you got -- That would still pass as being ductile and then you would run more tests at a higher ECR until you found the brittle transition.

MEMBER ARMIJO: Yes. Just looking at the scale, Paul's right. You know, this would be much more than 2.0-3.0 percent even that lowest datapoint. But there is a lot of scatter in the test that they performed. And the Argonne experiments didn't have that extent of scatter. They had some. But that's why we're doing the round-robin to nail that down.

But when you get down to that the hydrogen content of which you go from ductile to brittle would be different using a different test, I just want to make sure whatever test we do we can say it's equivalent or conservative.

MEMBER SHACK: If you look at higher ECR like the 10 percent.

MEMBER ARMIJO: Okay.

MEMBER SHACK: And then you get more comparable results between the two when they're --

MEMBER ARMIJO: That's why I asked for it to be in tabular form. These are data. These are drawings and they're right down between zero and one. We need an expanded scale, a log scale or something.

MS. FLANAGAN: Yes.

MR. CLIFFORD: But just for comparison at 10 percent ECR at 75 ppm that still would be considered ductile. I believe the limit, the analytical limit, is up at 17 percent at that load.

Do you have the analytical limit from the reg. guide?

MS. FLANAGAN: Yes.

MR. CLIFFORD: I mean, you have to get close to what the limit is as a function of hydrogen before you would see this transition and you would get tests on both sides. That way we were just looking at below 100 ppm. You're still at 16 percent or so. That was only at 10. So we would expect that to be ductile.

MEMBER ARMIJO: Okay. Well, we have some questions and I think we probably shouldn't spend more time on this because I don't think -- Perhaps after the public comment period we'll have more stuff. And it would have been nice and I read Argonne did a tremendous amount of work but did not that I could find do any three point bend test to compare their -- It would have been helpful.

But anyway that's what we have. Let's move on. I think, Michelle, that's all you've got.

MS. FLANAGAN: Yes.

MEMBER ARMIJO: Any other questions?

(No verbal response.)

Your next presenter. Ken, EPRI.

(Off the record comments.)

MR. YUEH: Good morning. My name is Ken Yueh. I'm with the Electric Power Research Institute.

(Off the record comments.)

Today I'm going to present some complimentary test results that we have conducted and also plans for the LOCA round-robin testing. Most of the tests are conducted because research conducted or sponsored by regulatory bodies usually done at limiting conditions and even some international programs sponsored with a lot of regular participation also in that direction.

I'm going to be talking about results in three areas with doing some high temp oxidation test at low temperatures. We're going to be presenting preliminary results. And we did some extensive evaluation of potential for inner diameter oxygen pickup. And then the last topic is LOCA round-robin test plans.

The high temperature oxidation, we began this test because preliminary data reported by ANL indicated that Zircaloy-4 had higher allowable ECR at the same hydrogen level and lower temperatures. So we started this test and we wanted to generate data at lower temperatures.

And when we started planning for this test, we planned on testing three temperatures, 1050°, 1125° and 1200° Celsius. The 1200° Celsius is mostly a benchmark to the ANL data. So we will not do a full test matrix for that.

And then at the time the proposed regulatory curve stops at 600 ppm hydrogen. So we were wanting to demonstrate that the ductility does not go to zero at above 600 ppm hydrogen.

And then the last point determine the feasibility of an embrittlement model, I think IOSN is working on a model on this. And we started on this because we actually obtained a few test samples from the ANL program. And we did some oxygen evaluation which shows the oxygen level is different at different PCT as temperature. And also the hydrogen modifies the oxygen segregation within the sample. So we think it's feasible to develop a model taking into consideration of LOCA temperature cycle and be able to predict when embrittlement would occur.

These preliminary results from one of the test temperature, 1050°C, against the embrittlement

ECR at the low temperature. It's much improved compared to the 1200°C. We're still working on the 1125°C and 1200°C analysis. But our initial data is just in that the initial test result may be more restrictive compared to the ANL test data.

Just to summarize, the temperature effect of higher embrittlement ECR at low temperatures is clearly demonstrated. And it's a point earlier about using ring compression based testing. I think it's very conservative in that when the LOCA scenario is analyzed the acceptance criteria is the peak cladding temperature. While the actual temperature profile is a profile where you spend very little time at the peak cladding temperature. So most of the time will be spent below that temperature and in effect the allowable ECR could be higher.

So our recommendation, I think the ACRS previous meeting, it recommended to include some of the elements. But additionally going forward we do not know how detailed the LOCA methodology will need to be. It's possible that they need to go into pin-by-pin census evaluation. And if that's the case then we would request that a pin specific PCT be allowed and possibly interpolation if we get more curves. You know, if you have small steps in temperature, interpolation begin the curve. And eventually if we can show, demonstrate, that we can predict the embrittlement through a model that would be ideal.

We move onto ID oxygen pickup. The NRC announced the inclusion of two-sided oxidation away from the ballooned and burst region in the rule. Some burn-up threshold justification with this was cited in the Halden report, IFA650.5 test. The test sample reached a peak cladding temperature of 1050°Celsius.

Based on some data, evaluation of that data and some other data, we have an alternative hypothesis. The original citation was based on a measured OD alpha phase thickness at the inside of the clad is the same as the outside. So our hypothesis states it's not necessarily the ID oxygen. So its pickup is the same as outside in the original hypothesis that the oxygen from the bonded fuel can be transferred into the clad. Okay.

The experiment evidence does not show that. In fact, we're going to make a case that the internal oxygen sources may be limited to the pre-transient oxide.

And in the next slide is experimental evidence that supported further testing for us. On the top left-hand corner is a picture from the ANL

Limerick Test. The test rod had I think 57 to 60 gigawatt-day MTU burn-up. It was confirmed there was --

MEMBER POWERS: Where was this?

MR. YUEH: I'm sorry.

MEMBER POWERS: What alloy was Limerick?

MR. YUEH: This was Zircaloy-2.

MEMBER ARMIJO: Zircaloy-2, yes, BWR.

MR. YUEH: Yes. So before the test there was a fuel clad bonding layer. After the test clearly on the outside there's the oxygen stabilized alpha layer, but it's not visible on the inside. So it's just it is not equivalent. You cannot get unlimited oxygen transfer from the fuel.

And these two pictures are the NRC citation from the Halden test report. The Halden report also suggested that the oxygen for the oxygen stabilized alpha layer comes from the fuel. But in fact in a typical fuel clad bonding structure, there is an oxide layer typically around 10 microns. Even at the end of a life, it's about 10 microns. That 10 micron oxide has enough oxygen to form this layer.

MEMBER ARMIJO: Okay.

MR. YUEH: So the absence of significant observed fuel-clad reaction in both Halden and ANL tests this suggested that oxygen transfer from bonded fuel is limited and may be limited to the pre-transient oxide. In the next few slides, I will show some of the work we have done to support our hypothesis.

In the first test that was done just to simulate the Halden test showing the oxygen stabilized alpha layer we took a Zircaloy clad capsule pre-oxided to 7 microns and sealed it on both the ends. So the oxygen is limited to the 7 microns of oxide similar to the fuel bonding layer that oxide. In our test we also replicated a similar oxygen stabilized alpha layer. So that shows that. The feasibility of that layer comes from the oxygen.

In the second type of test where we actually put non-irradiated fuel pellets into the capsule, we have multiple geometries and conditions for these capsules. One is where we use enlarged pellets so that at temperature the pellet would enlarge more than the clad. In some you would have contact. And in some of the other cases where the pellets are smaller, it would not use any significant contact pressure.

In our test, half of the sample independent of the contact pressure showed localized pellet-clad reaction. And this is an example of the type of reaction you can have. So our position is if there is transfer of oxygen from the fuel to the clad there should be evidence left behind from this reaction layer.

Now if you zoom into the area, you would actually see uranium zirconium intermetallic. It was found there. You can actually see that.

CHAIRMAN ABDEL-KHALIK: Where were these tests conducted?

MR. YUEH: These were conducted at GNF, Vallecito's (phonetic) lab.

CHAIRMAN ABDEL-KHALIK: Okay.

MEMBER ARMIJO: Okay. But this is part of -- perhaps it will be in the comments related to the reg. guide. But assuming if you can make your case to the satisfaction of the staff your proposal would be that two-sided oxidation and fuel-clad bonding as the source of embrittlement is not valid.

MR. YUEH: And I will make a case at the next Halden meeting to look at if it's possible some of their tests. Because in the previous Halden tests, they were focused only near the burst region. So near the burst region there's a supply of steam in there. So a lot of data can be obtained. It may be possible that they have some samples away from the burst region. There may be a couple of samples they've got already, but they have not focused to look at the fuel bonding reaction. So the data, the test sample may be out there to look for this kind of evidence whether it's there or not.

MEMBER ARMIJO: Okay.

MR. YUEH: Whether this reaction takes place or not.

And after that we're thinking the oxygen source may be limited. So we want to quantify what is the impact if you have limited oxygen source.

In the top we have open two-sided oxidation as a function of pre-oxidation. So this would be totally open capsules. And you can see that there's no correlation, very little correlation, between pre-oxidation and the time to embrittlement. Except at the higher pre-oxidation, the one sample that we expected to be brittle was actually that graph.

In the case where we closed the capsule -- so we have pre-amount of oxidation, fixed amount of oxygen side we closed it. So the inside oxygen is limited -- we can see that the time to embrittlement is much increased. Obviously, if you have no oxygen flow on the inside and we have 10 microns and it's typical fuel-clad bonding thickness, it's still much improved to the open case. So this difference diminishes the time you get to 20 microns of oxide.

MEMBER ARMIJO: Are all these tests based on ring compression tests as defining --

MR. YUEH: On ring compression tests, yes.

MEMBER ARMIJO: Okay.

MR. YUEH: These ring compression tests were not quenched in water. The difference is they were cooled in air. So it was withdrawn from the heated zone into just cold air.

Our tests confirm that this stabilized alpha phase cited in IFA-650.5, the Halden test, could be generated from a pre-transient oxide. And we do acknowledge that there's a limited potential for pellet-clad reaction, but it's very localized.

MEMBER SHACK: Well, those tests that you have, there's still no metallurgical bond there. You did with an un-irradiated -- It doesn't look anything like a high burn-up.

MR. YUEH: It does not.

MEMBER SHACK: On interface. So I'm not sure what its relevance is to this discussion.

MR. YUEH: The relevance is if you have

reaction between the fuel and the clad there should be some -- If you take away oxygen from the fuel, then the uranium is free. Right. And the uranium would react with zirconium. There should be intermetallic uranium zirconium compound in the area. So regardless whether the fuel is bonded or not, if you take away oxygen, there will be a reaction.

MEMBER POWERS: I guess I'm lost. You've got -- First of all, what is the intermetallic?

MR. YUEH: It's just uranium and zirconium.

MEMBER POWERS: Yes, it's stoichiometry. I know what it looks like.

MR. YUEH: I have not measured the stoichiometry. It's part of UZR. There's some ratio. I do not know at this time whether it's one-to-one. We do have the sample. We can go measure it. And this is also reported I think in the original Hoffman (phonetic) study.

MEMBER POWERS: Okay. Now you run a test with substoichiometric urania in a clad.

MR. YUEH: Yes.

MEMBER POWERS: There's no oxygen to give up.

MR. YUEH: There is just localized oxygen given from the fuel.

MEMBER POWERS: There's no oxygen to give up in substoichiometric urania.

MR. YUEH: But zirconium affinity is higher than uranium.

MEMBER POWERS: In substoichiometric urania the oxygen potential is less than the phase boundary between zirconium and zirconium dioxide. There's no oxygen to give.

MR. YUEH: If that's the case, then we don't have to make the case. Right. Then the amount of oxygen on the inside would be limited to the oxygen freed from the --

MEMBER POWERS: That changes as soon as you start irradiating it.

MEMBER ARMIJO: Right. So I guess I'd come back to Bill's question --

MEMBER POWERS: Why is this --

MEMBER ARMIJO: Without an irradiated I think it's --

MEMBER POWERS: What are you telling me with that un-irradiated test?

MR. YUEH: Even without irradiation, I think whether you have irradiation or not if you have oxygen transfer in the irradiated case -- Okay.

Thermodynamically in a non irradiated case, you cannot have a transfer. Then we don't need to make the case and your point is it's not very useful.

But our data is showing that even in the fabricated condition there is an oxygen transfer in localized areas.

MEMBER POWERS: As far as what I could tell what you showed is there's a uranium potential in substoichiometric urania and that the clad will equilibrate with that in the only way it can and that's to accept uranium into itself. And you precipitated out an intermetallic. That's what you showed.

MR. YUEH: Yes, but if that's the case if you form that where does the oxygen go?

MEMBER POWERS: The oxygen's right where it's supposed to be.

MEMBER ARMIJO: Yes. I think you can't make a case from un-irradiated tests. And the other issue I have on two-sided oxidation is you've got an open structure there. You've got plenty of -- So of course the temperature great transient's been over.

MEMBER POWERS: The oxygen potential must be around what? -650 gigajoules.

MEMBER ARMIJO: That's very stable.

MEMBER POWERS: I mean megajoules.

MEMBER ARMIJO: It's very stable.

MEMBER POWERS: Yes. There's no oxygen to give in the substoichiometric urania. In fact, what you have is a uranium metal potential in the fuel and it did just exactly what it's supposed to do. It's supposed to equilibrate with the clad and did so. And you reach the solubility limit and precipitate it out in intermetallic phase.

MR. YUEH: You're speaking of the normal operating condition or the LOCA.

MEMBER POWERS: No, I'm speaking of your test.

MEMBER ARMIJO: Yes. I think you've got to do a lot more with the irradiated samples, irradiated fuel cladding. You've got to really understand the thermodynamics of the various phases.

MEMBER POWERS: Or just go up to 2.001 on the stoichiometry and you'll get the oxygen potential up and then it will transfer.

MEMBER ARMIJO: Right.

MEMBER POWERS: I mean what you've demonstrated is indeed that the clad tries to equilibrate with fuel. And it does it in whichever potential it has to ameliorate.

MEMBER ARMIJO: But for the fuel --

MEMBER POWERS: It was right all the time.

MEMBER ARMIJO: But for the fuel to be the source of oxygen during that transient --

MEMBER POWERS: It's got to have oxygen.

MEMBER ARMIJO: -- it's got to have the oxygen and it also has to -- the kinetics of the fuel releasing its oxygen and going into the cladding could be limited. You've got to work that side of it rather than ex-reactor tests on substoichiometric UO_2. I don't think that's going to make your case. But that's something that the industry folks are working on and you're going to have to present that at the appropriate time to the staff and see if you can persuade them that you have a good argument.

But right now what I think we are most interested in -- I am -- is the LOCA round-robin testing. What progress is being made there? What problems are you having? And ultimately we're all going to rely on this test and we'd sure like to make sure that everybody gets the same or essentially the same results with it with the same material independent of laboratory.

So do you want to move onto that, Ken?

MR. YUEH: The LOCA round-robin, the goal is to identify and evaluate sources of variation between laboratories and experimental areas. And we have a second goal of generating sufficient test data to support ASTM test procedures.

After we've solicited laboratories for participation, we set a basic framework amongst the labs. As an ASTM requirement, we're required a minimum of five laboratories to be able to support a test procedure.

Within the framework, everybody agreed to follow key technical requirements consistent with ANL recommendations. So these will be high level requirements like temperature profile. Some of the minor requirements may be different like what's water used to generate the steam.

MEMBER ARMIJO: Now those experimental requirements are right out of the draft reg. guide. Is that right?

MR. YUEH: Correct.

MEMBER ARMIJO: So there's no -- There may be some minor things that you couldn't meet. Each laboratory couldn't run exactly the same test as Argonne. But there should be very minor differences.

MR. YUEH: The experimental setup of the laboratories, we are going to have different test conditions.

MEMBER ARMIJO: Okay.

MR. YUEH: So in INOL (phonetic) recommended procedure the range is greater than what's actually used in the test at ANL. So we are staying within the recommended ranges.

MEMBER ARMIJO: Okay.

MR. YUEH: So we will perform common sets of tests using the same lot of material and the material is Zircaloy-4.

MEMBER SHACK: Now I recall back in the Subcommittee there was some discussion about who was going to put the hydrogen into the material. Right?

MR. YUEH: Yes. All the labs are to charge their own samples.

MEMBER SHACK: Okay.

MR. YUEH: So right now I think we have only provided hydrogen precharged material to one of the labs. I think one of the labs, Studsvik, is going to drop out because their equipment has gone into the hot cell.

MEMBER ARMIJO: So you will only have four laboratories?

MR. YUEH: We will still have six.

MEMBER ARMIJO: Six.

MR. YUEH: We have seven altogether.

MEMBER ARMIJO: Okay. So a minimum of five and you've got six after Studsvik drops out.

MR. YUEH: Yes, six.

MEMBER ARMIJO: Okay.

MR. YUEH: And early on one of the things that we want to do is to allow the labs to use their own test procedures. So this would afford people the greatest flexibility if the round-robin results come back and everybody gets similar results. And we also envision that if not we may have to go tighten the parameters. That's a possibility.

MEMBER ARMIJO: But have you reviewed the test procedures to make sure that they aren't doomed to failure? You know, reviewed the test procedures and compared them with the Argonne test procedures and say that it's close enough. It would be a waste of time if you could have identified a flawed test procedure in advance and didn't do it.

MR. YUEH: Got to keep in mind the parameters are within the ANL recommended procedure, the key parameters.

MEMBER ARMIJO: Okay.

MR. YUEH: It's only minor variables may be different. Only a couple of cases they're different and one of them is the greater water use.

CHAIRMAN ABDEL-KHALIK: Could you repeat that again?

MR. YUEH: The greater water, the purity of the water used.

CHAIRMAN ABDEL-KHALIK: Okay. Thank you.

MR. YUEH: How hydrogen analysis is performed. ANL described a specific procedure for determining that. And other people have determined hydrogen values using other methods. So we would allow other methods that are approved by their own QA program.

CHAIRMAN ABDEL-KHALIK: Okay.

MR. YUEH: We have defined a basic data collection, what kind of data needs to be collected. And the data is to be shared amongst all participating members.

This is the text matrix that people are going to be using. As was mentioned earlier, the temperature profile is going to be ANL-like. In this case, the peak cladding temperature will be 1200° Celsius. So we will determine that embrittlement ECR in the as-built condition and 200 and 400 and 600 ppm hydrogen.

We had some problem targets with specific hydrogen values. So they may end up different from these specific values. But we had requested that they measure the hydrogen values near the samples used in ring compression test. And the test matrix, just recommend some target range for people to bracket the embrittlement ECR.

On breakaway oxidation, once again the temperature profile, the heat-up and cool rates, is recommended same as in our recommendation. And the labs will determine the breakaway oxidation at 800° and 1000° Celsius to within 500 seconds. And the labs have been instructed to terminate the tests if they have not bracketed by 7000 seconds. I think most people --

MEMBER ARMIJO: I didn't understand. I didn't hear you, Ken. You have to speak a little louder.

MR. YUEH: They are supposed to do these tests every 500 seconds. Let's say you expect at 5,000 seconds. Maybe the first one will be 4500 seconds. And they keep on increasing until you see breakaway.

MEMBER ARMIJO: Okay.

MR. YUEH: By the time they get to 7,000 seconds if they still don't see it they will terminate it.

MEMBER ARMIJO: Just let me ask the staff. Has Office of Research looked at this matrix and commented to EPRI if whether there's something serious missing or it looks acceptable?

MS. FLANAGAN: We haven't been asked for comment. But I think that is the center value there is where we expect embrittlement. So to go two above and two below would be what is suggested by the regulatory guide. So we haven't yet. But in this moment I can say that that's a reasonable test.

MEMBER ARMIJO: The whole point is that whatever they do when it's done it will be -- You'll accept it.

MS. FLANAGAN: Right.

MEMBER ARMIJO: So if their test matrix is off a great deal, they should know right away.

MS. FLANAGAN: Yes. This is the first time I've seen the test matrix.

MEMBER ARMIJO: Yes. Okay.

MS. FLANAGAN: So, no, we haven't commented formally on it.

MEMBER ARMIJO: There's another thing that I asked and I guess it will come out in the next chart. I asked it at the Subcommittee meeting and that is this is one material that everybody is going to test. All of them or most of them are going to do their own hydrogen charging. So that's going to introduce a variable. But that's what you have to do anyway.

But to me the reference laboratory is Argonne because they've developed the test, perfected it. But they're not testing the same material. And it just seems to me that we should want to anchor the industry test program to not only the procedures that Argonne developed but verify that everybody tests including Argonne the same material under the same condition. We get a reasonable level of consistency. And that's not included in the current program and I think it should be.

MR. YUEH: We have asked for Argonne's participation. From the last meeting, I said they have declined. I think they're waiting for some funding from the NRC to join the round-robin. It's still possible. We have plenty of materials. So if they want to --

MEMBER ARMIJO: Okay. Well, that's something that we want to, the Committee, comment on in our letter.

MR. SCOTT: Doctor, we hope -- This is

Harold Scott from Research.

MEMBER ARMIJO: Yes, sir.

MR. SCOTT: At the Subcommittee meeting, we did talk about this. When I got back to the office, my colleague said to me, "Harold, why don't they use the existing Argonne data?"

The only question might be is to whether there is some lot-to-lot difference. In other words, if the material that you provided, the Zirc-4 -- We did modern Zirc-4. So I think the question might be we should take the data that Argonne already has, throw it in the mix and sort of see where it comes out.

MEMBER ARMIJO: That's not my understanding of a round-robin. But other members of the Committee may look at it. I just want to nail this thing down that there's no question. And they tested different material. The expectation, my expectation, is everybody will be the same. But I want to make sure.

Now the other members may not agree with me. But that I think is a little problem.

MR. YUEH: Yes. And my personal opinion is that probably in Zircaloy-4 there should not be a lot of difference especially if similar era because even within a lot you can have variations perhaps even larger than between lots. There's a possibility of that.

MEMBER ARMIJO: Okay. Look. That's just an issue that I raised.

MR. YUEH: Yes.

MEMBER ARMIJO: But we can go on.

MR. YUEH: These are the seven laboratories. I think Studsvik may drop out. Oakridge is a little bit behind. They're still constructing their apparatus. Three of them I think are pretty much complete with the test. The two vendors will probably complete their tests later on in the summer.

This is all the milestones. So we're hoping to complete the tests by the summer. And after that we will distribute the data to the participants and ASTM. And after that we would review the data with NRC as far as our evaluation of the data with ASTM. And then draft an ASTM procedure.

MEMBER ARMIJO: So you're talking within a couple of months all the laboratories will be finished with this testing.

MR. YUEH: It's probably later in the summer than beginning of the summer.

MEMBER ARMIJO: We're in the summer I thought. It's been a long winter.

MEMBER POWERS: Yes, it's been a long winter.

MEMBER ARMIJO: It's been a long winter for me anyway. Okay.

MR. YUEH: Because I mentioned last time we have no contractual agreements with any of the labs. So they are all volunteers. So they do it whenever they have the time.

MEMBER ARMIJO: I would think that the industry guys would be sort of committed.

MR. YUEH: They are committed to complete the tests. It's a matter of when they can get to this.

MEMBER ARMIJO: Okay.

MR. YUEH: So these are the steps that we envision. I think that's the last slide.

MEMBER ARMIJO: Excellent. And this was just an example of your hydrogen charging set-up.

MR. YUEH: The back slides?

MEMBER ARMIJO: Yes.

MR. YUEH: No, this is the apparatus used at AEKI for the oxidation test.

MEMBER ARMIJO: Okay. For that experiment you were talking about.

MR. YUEH: Yes. And the second back-up slide shows the open case and the closed case where you have controlled amount of oxygen on the inside. So this is a very big difference.

MEMBER ARMIJO: Thank you.

MR. YUEH: You're welcome.

MEMBER ARMIJO: Are there any questions or comments from members?

(No verbal response.)

We have Mike Billone on the bridge line. Mike, do you have any comments?

(Off the record comments.)

MEMBER ARMIJO: Just hold on, Mike, if you have something to say. We're opening up the bridge line. I think we can wait a couple of minutes since we're well ahead of schedule.

I want to thank the presenters for doing that. In the meantime, let me just check.

Bill, comments?

MR. BILLONE: Hello.

MEMBER ARMIJO: There he is. Okay, Mike.

MR. BILLONE: Hello?

MEMBER ARMIJO: Yes.

MR. BILLONE: I have a very quick comment on Michelle's slide 12 which compared the rate compression test to three point bend test. And a quick comment is that these are, as Bill Shack correctly pointed out, offset strains. And the brittle-to-ductile transition is 2.0 percent offset strain for the ring compression test. So all four values listed are below that. They're in the --

MEMBER ARMIJO: Okay. That helps a great deal.

MR. BILLONE: And then the three point bend test very quickly there is none because you can't measure permanent strain with sample break for the two pieces. So I've set an offset strain limit of 0.25 percent for those tests. So two of them will be brittle. One would be ductile.

I don't know if that helps.

MEMBER SHACK: Well, it makes conservative anyway for you, Sam.

MR. BILLONE: Right.

MEMBER ARMIJO: That's what I'm looking for. Okay.

MR. BILLONE: Yes.

MEMBER ARMIJO: That the ring compression test will always show brittle behavior and therefore will always be on the right side of the embrittlement curve. And that's -- Okay. I understand what you've got here now. That helps a lot. Thanks a lot, Mike.

MR. BILLONE: Okay.

MR. SCOTT: Let me just remark, too. I think that this is actually the Orlando paper. The reference probably should be the 2010 Orlando paper, not the other.

MR. BILLONE: Yes, Harold's correct.

MS. FLANAGAN: Yes.

MEMBER ARMIJO: I don't know if this is the Orlando paper. There's the paper that Mike Billone sent me.

MEMBER SHACK: The Orlando paper, is that the 2007 ASTM?

MEMBER ARMIJO: I'm looking for a date here.

MR. BILLONE: No. The Orlando's 2010.

MEMBER ARMIJO: Yes. September 2010. That's the one I've got.

MR. BILLONE: Yes. These numbers come from that paper. So the reference at the bottom needs to be updated.

MEMBER ARMIJO: Okay.

All right. That's it. Mr. Chairman --

MR. MEYER: Will you take another comment?

MEMBER ARMIJO: Sure. Would you identify yourself please?

MR. MEYER: Sure. This is Ralph Meyer.

MEMBER ARMIJO: Ralph, I didn't recognize your voice.

MR. MEYER: I think someone needs to say that the emperor has no clothes with regard to the reg. guides. There's a flexibility implied by having the reg. guides that vendors or manufacturers are going to be able to get different oxidation limits for different cladding types.

It's just not going to happen. We tested a lot of different cladding types at Argonne and got the same answer for all of them as you increased the hydrogen content.

The embrittlement process that we're looking at depends on interstitial diffusion of oxygen and dilute zirconium alloys and it's just not sensitive to impurities like the alloy constituents. NRC or Argonne combined have proposed an oxidation limit as a function of hydrogen content. It's been pretty well vetted. I don't think anybody has any real concern about it.

The industry, EPRI, have made some results at lower temperatures, made some tests at lower temperatures. I haven't seen the results in detail. But what I did see from the Subcommittee meeting looked pretty good.

The industry had proposed that you take the oxidation limits at lower temperatures and at 1200° Centigrade and combine them to get a family of curves. I think that's an excellent idea. You can just put those right in the rule. The rule is within the inherently performance-based because the guy who can make a cladding that picks up less hydrogen gets a higher limit.

And then you wouldn't need all the reg. guides and all the testing business. I just don't think you're going to get anything out of it. That's my comment. Thank you.

MEMBER ARMIJO: I appreciate that, Ralph. I think anything that would simplify it and still have a performance-based rule that has built in flexibility all you have to do is demonstrate you comply would be a very good thing to have. But we really haven't gotten to that point yet and this is where we are.

But I do appreciate the idea if it could actually be pulled off.

CHAIRMAN ABDEL-KHALIK: Ralph, can you say with certainty that your statement is true for all future alloys that anybody might come up with?

MR. MEYER: Of course, I can't say with certainty it would be true.

CHAIRMAN ABDEL-KHALIK: So what's the point?

MR. MEYER: I do know that we tested quite a number and we have at least a plausible understanding of how this all takes place. I would suggest that it should not be sensitive to alloy composition.

I think it's perfectly reasonable for NRC during its licensing topical review report of a new cladding material to ask for a few tests, ring compression test, similar to the database to show that it is still in compliance with the limit that could be in the rule. So you could have those kind of protections without having the elaborate framework of regulatory guides and an expectation that there's going to be big variations and manufacturers are going to have lots of flexibility which I don't expect to be present.

MEMBER ARMIJO: Okay. But, Ralph, in your approach, you come in with a new material and you're going to demonstrate that it's compliant with the rule that's either got a table or graphs or something that says this is what you've got to comply with. They still would have to have some sort of a test procedure or methodology to satisfy the staff that they are compliant with the rule. So you would need something like a reg. guide anyway.

MR. MEYER: Well, not necessarily. This type of thing is done for many materials' properties in qualifying a new material. And the test procedures that have been used by Argonne and other labs historically are well documented. And as long as they use test procedures that are reasonable in light of the experience that we have, that's a reviewed item and a reviewer I think could make a reasonable judgment.

MR. BILLONE: Mike Billone disagrees with Ralph on this. You need a test procedure and the documentation on what CEA does and what Westinghouse does usually is not elaborate enough. Usually it's open literature for publications.

MEMBER ARMIJO: So it would put a burden on the staff and the applicant to negotiate accepted --

MEMBER SHACK: An ASTM qualifying test might make a difference.

MEMBER ARMIJO: Would be ideal. Yes.

MEMBER SIEBER: So would a reg. guide.

MEMBER ARMIJO: Yes.

MEMBER SHACK: And I think for many of the things that the staff accepts without a reg. guide that's because there's an ASTM or some equivalent consensus approach to it.

MEMBER ARMIJO: Well, you know, if the industry activity actually developed an ASTM procedure or standard, then the reg. guide would just reference that and that would be it.

MEMBER SIEBER: Just follow the ASTM.

MEMBER ARMIJO: Okay. Well, Ralph, I appreciate --

MR. MEYER: That would be a reasonable compromise to have the reg. guide for testing and still have an oxidation limit in the rule and to use the reg. guide to demonstrate continued appropriateness for new materials. But I do fully expect the new materials as long as they're dilute zirconium alloys to be the same result.

MEMBER ARMIJO: It would be the same. Right. The only difference being their hydrogen pickup during service.

MR. MEYER: Yes, and that's explicitly accounted for in the results that we already have.

MEMBER ARMIJO: Thank you, Ralph.

I think -- Any other comments? Questions?

(No verbal response.)

Okay. Well, I'd like to thank Paul, Michelle and Ken for very interesting presentations. I think you cleared up a lot of points and particularly the offset strain thing.

In the future, Michelle, always put a label on your chart. It will save you a lot of grief. Thank you.

Mr. Chairman, it's all yours.

CHAIRMAN ABDEL-KHALIK: Thank you. We are a little early, but nevertheless we'll stick with the schedule. Our schedule calls for us to take a break and reconvene at 10:45 a.m. at which time we will discuss the revised safety evaluation report associated with the license renewal application for the Hope Creek Generating Station. So we will reconvene at 10:45 a.m. Off the record.

(Whereupon, a short recess was taken.)

CHAIRMAN ABDEL-KHALIK: At this time we'll move to Item 3 on the agenda, Revised Safety Evaluation Report Associated with the License Renewal Application for the Hope Creek Generating Station. And Dr. Schack will lead us through that discussion.

MEMBER SCHACK: Okay. We've discussed the license renewal for Hope Creek at a Subcommittee meeting on November 3rd, and at our last full Committee meeting, and addressed most of the issues involved. However, there was some late-breaking information about the configurations of the drains for the dry well air gap that the Staff needed to consider in the SER, so we didn't complete a letter last time.

Today, you'll hear a presentation from the Applicant on the configuration of the dry well air gap drains and their plans for dealing with the issue, and from the Staff on the resulting changes to the SER. We'll also hear a little bit more about the testing techniques used for 480 volt cables. And I'll turn it over now to Brian Holian of the Staff.

MR. HOLIAN: Good. Thank you. Good morning, Committee. My name is Brian Holian. I'm the Division Director for the Division of License Renewal. The agenda for today is to follow-up on the Hope Creek meeting that we had a month ago. I'll just do brief introductions, and a brief opening comment, and then we'll turn it over to the licensee for their perspective on these couple of issues that were still left to be resolved at the last monthly meeting. And then that will be followed by the Staff's perspective on what we did in the Final Safety Evaluation Report writeup.

Just brief introductions, and then I'll introduce the rest of the Staff right before they present. But to my left is Melanie Galloway, the Deputy Director for Division of License Renewal. I do want to highlight, I believe on the phone, if not now he will be, Rich Conte, the Division Director from the Division of Reactor Safety for Region I. He'll be joining us by phone. And one other highlight on Staff presentation, also Bo Pham, the Branch Chief for Hope Creek is behind me. And I wanted to highlight Tom Koshy, who's the Research Branch Chief for electrical issues. Tom has presented before the Committee on multiple occasions, and he's here, in particular, to support the electrical discussion.

I know in license renewal it often comes up what are we doing in license renewal for aging management, but it also goes to some of the research work that's looking at what are we doing even in Part 50 ongoing with draft reg guides for ongoing testing. So, he'll be a key participant in the Staff later on.

I do want to thank the Committee for another opportunity at Hope Creek. This is a good example, this dry well air gap issue, of the kind of issues we wrestle with throughout the 22 and 24-month review schedule that we're on. And last month on May 12^{th}, the discussion clearly showed that our review takes up that full 22 to 24-months, and all the way up to the last minute. And we were still wrestling a little bit with the utility and ourselves on the license condition that the Committee should have received in this last month.

It's easier for us to take an issue this like when the safety evaluation is already done and kind of fine tune it into a license condition, which is what we did on this issue. So, I think you'll see a comprehensive license condition that kind of addresses the testing they'll be doing, and other Staff will be monitoring and inspecting that. So, we look forward to that discussion.

With that, I'll turn it over to Paul Davison from Hope Creek, and he's the Vice President of Operations Support. Paul.

MR. DAVISON: Thank you, Mr. Holian, and good morning. My name is Paul Davison. I'm the Vice President of Operations Support at PSEG Nuclear, and I'm also the Executive Sponsor for the license renewal.

This presentation will provide you with an update on two topics of interest from our May 12th, 2011 presentation for Hope Creek. Those two topics are the dry well air gap drains, and low-voltage power cables.

Before we begin today's presentation, I would like to introduce the presenters. To my right is Jim Stavely from the License Renewal Project. Jim has 25 years of nuclear power plant experience, 15 with PSEG Nuclear. To Jim's right is John Hilditch, the Electrical Lead for the License Renewal Project. John has 28 years of nuclear power plant experience, including 15 years at PSEG Nuclear. In addition to today's presenters, we also have with us today Bob Braun behind you, PSEG Nuclear Senior Vice President for Nuclear Operations, and John Perry, the Site Vice President for Hope Creek.

Slide two shows our agenda for the presentation where we will discuss the two topics of interest. We look forward to answering any questions you may have either during or after the presentation. And I will now turn it over to Jim Stavely, who will begin the presentation.

MEMBER ARMIJO: Paul, before you go on.

MR. DAVISON: Yes.

MEMBER ARMIJO: John's name card shows

Exelon, and you said he was a PSEG. Could you clarify?

MR. DAVISON: Sure. John, I said John is the Lead Electrical individual for the license renewal project. He has 15 years -- he has had 15 years with PSEG Nuclear. He has recently actually left PSEG and joined Exelon in a full-time capacity as the Electrical Lead in their license renewal project.

MEMBER ARMIJO: But he's working for you in this capacity.

MR. DAVISON: That is correct.

MEMBER ARMIJO: Okay. Thank you.

MR. STAVELY: Thank you, Paul. Slide 3, please.

Good morning. My name is Jim Stavely. As part of our presentation at the ACRS Full Committee Meeting on May 12th, 2011, we provided information on the Hope Creek Mark I containment as a topic of interest.

At that time, PSEG Nuclear and the Staff were finalizing commitments associated with the dry well air gap drains. Today's presentation provides an overview of the dry well air gap drains and describes the commitments. Slide 4, please.

I will transition back and forth from this slide to other slides to show a sketch or a photo associated with some of the major bullets. I will cover all the information on the slide.

During the 2009 refueling outage with the reactor cavity flooded, we observed water trickling out of a penetration sleeve in the torus room. Similar leakage was observed in the 2010 refueling outage with a maximum rate of approximately 100 drops per minute. In both outages, the leak stopped when the reactor cavity was drained. Slide 5, please.

This sketch shows the configuration of the containment during refueling outage with the reactor cavity flooded. The dark blue line starting from the reactor cavity seal area and continuing down into the dry well air gap is the most probable path for the leakage. The most probable source of the leak is a small weld defect on the seal plate in the reactor cavity seal area.

Actions are being taken to determine the source of the leak, and repair it, if possible. Note that this leak is not a leak in containment, but a leak outside of containment that has the potential to occasionally wet portions of the exterior surface of the dry well shell two weeks every 18 months during refueling outages.

The containment design includes drain lines at the bottom of the dry well air gap that discharge onto the torus room floor. Based on boroscope examinations performed during the 2010 refueling outage, these drain lines are blocked and are not capable of draining water from the air gap. The boroscope examination showed plugs in all four drain lines. Slide 6, please.

The drain lines are at azimuth zero, ninety, one-eighty, and two-seventy. This is a photo of the plug in the drain line at azimuth zero. You can see on the outside the four-inch carbon steel pipe, and then the cover, or plug, the plug in the middle. The plug is representative of the plug in the other three drain lines.

MEMBER STETKAR: The only access you have, Jim, is from the torus room. Right? This is from the torus room looking into the drain line.

MR. STAVELY: Yes, this is the access from the torus room.

MEMBER ARMIJO: Is that a metal plug, or concrete, or do you know?

MR. STAVELY: When we pushed against it, we did insert tooling, and we inserted a pole in it and pushed against it, and it dimpled a little bit showing it had some resiliency to it, but we're not positive on the material yet. Our next actions include drilling through the plug and removing it to see what is on the other side, recognizing that even though we do believe right now it's in between the -- in the middle of a shield wall, we have to take care because of the dry well shell.

CHAIRMAN ABDEL-KHALIK: Could you go back to the previous slide, please?

MR. STAVELY: Yes, please.

CHAIRMAN ABDEL-KHALIK: So, what you're hypothesizing is that you have a leak at the reactor cavity seal area, and that you have a film of water that's flowing along the wall, and eventually it just gets to that penetration sleeve and it leaks out? Is that what you're hypothesizing?

MR. STAVELY: Yes. Could we go to slide 18, please. This slide is a blowup of the reactor cavity seal area, again in a refueling configuration with the reactor cavity flooded. The dark blue line where you see the drips is -- the most probable location is a weld on that seal plate that is dripping onto the dry well shell itself, and then as the dry well shell curves it then transitions over the concrete wall.

CHAIRMAN ABDEL-KHALIK: That's my question. So, you're hypothesizing that you have a film of water going from that leak source, and it's flowing along the wall, and eventually it leaks out of this penetration sleeves?

MR. STAVELY: That is correct.

MEMBER ARMIJO: But it has to jump that gap from the steel wall to the concrete.

CHAIRMAN ABDEL-KHALIK: Can a film of water actually flow along this curved wall of the containment?

MR. STAVELY: We boroscoped the penetrations during the refueling outage, so when we inserted the boroscope into the dry well air gap and then turned around to take a look at the shield wall, the water was on the concrete shield wall. There was no water actually on the shell.

CHAIRMAN ABDEL-KHALIK: So, the water is in the gap between the steel and the concrete?

MR. STAVELY: That is correct. The design includes a nominal 2-inch air gap between the shell and the concrete shield wall on the other side of the shell, so a nominal 2-inch air gap.

CHAIRMAN ABDEL-KHALIK: So, it is possible that entire lower hemispherical area would be covered with water up to that level of the penetration sleeve?

MR. STAVELY: Let's go slide -- the dry well slide. If you take a look at this slide, again the drains are right there at the bottom of the air gap. You can see the vent line directly above the drains. There is a sleeve around that vent line, as well. So, if water was to accumulate in the bottom of the air gap, the maximum depth would be up to that sleeve around one of the eight vent lines, and then would flow out into the torus room in the same fashion that it would flow out of the drains. And that works out to approximately one foot five inches, and when we boroscoped the bottom of the air gap after draining the cavity in the 2010 refueling outage, there was no water accumulation at the bottom of the air gap.

CHAIRMAN ABDEL-KHALIK: So, were did the water that had accumulated in that one-foot elevation go?

MR. STAVELY: The size of the leak is a very small leak, so when we actually collected the sample and observed it, it was approximately 100 drops a minute at the penetration. Where it gets down -- when it continues down the shield wall, it's a very small leak. It's a higher temperature. It would evaporate.

CHAIRMAN ABDEL-KHALIK: Thank you.

MR. STAVELY: You're welcome.

MEMBER STETKAR: Jim, you said when you looked in the air gap you saw wetting on the surface of the shield wall.

MR. STAVELY: That's correct.

MEMBER STETKAR: Your little cartoon on whatever slide it was, the initial slide that showed the location of the leak would indicate that the water, at least on this cartoon, starts out adhering to the dry well shell. How does it get across the two-inch air gap? I mean, is there a sharp edge that it's dripping down? You know, where does it make the transition --

MR. STAVELY: We're hypothesizing it as -- let's go back to the slide of the entire dry well.

MEMBER ARMIJO: I have the same question.

MR. STAVELY: Okay.

MEMBER ARMIJO: I think slide 7 shows --

MEMBER STETKAR: Does it?

MEMBER ARMIJO: Yes.

MEMBER STETKAR: Okay.

MEMBER ARMIJO: It answered my question.

MEMBER STETKAR: Well, slide -- I can't say that. This one here shows how the water adhering to the shell, concrete dry well with the concrete eventually transitions into the gap around the instrument line --

MEMBER ARMIJO: It could be --

MEMBER STETKAR: My question is, how does it get from the dry well shell where it's shown in the previous slide, not that one, but the slide that shows the detail of -- number 5? That one I can say, slide 5.

MR. STAVELY: The hypothesis is as the curvature of the dry well, as it comes down and curves down, the surface tension is insufficient to maintain the water on the shell, and it transitions over the concrete. There is a coating on the shell, it's an organic zinc coating. It's in tact, it's in good condition, and so it's got a surface that it would just drip off when the surface tension versus gravity.

MEMBER SCHACK: He'd be very happy to have you believe it follows the concrete all the way down.

MEMBER STETKAR: I don't believe that. I just don't know how far it follows the steel down.

MEMBER ARMIJO: But even if it didn't drip off, it's still intercepted by the penetrations, even if it hugged the curvature --

MEMBER SCHACK: Well, if it hugged it

would accumulate down into the gap --

MEMBER ARMIJO: No, when it reaches these penetration lines, there's already a metal contact there, and it could start -- it's intercepted in either case.

MR. STAVELY: Potentially, yes. From the boroscopes, the penetration lines where they enter the dry well shell at that point are dry. There's no indication of any water on that area of the dry well shell, or those penetrations.

MEMBER STETKAR: At the weld area.

MR. STAVELY: Slide 7, please. This sketch shows the lower dry well area. The green line is the air gap drain.

In 2011, actions were initiated to remove the drain line plugs. Working with a contractor, tooling was selected and tests performed on a mockup. The drain line at azimuth zero was selected for the first plug removal. Access to the drain line from the torus room was required close to the point at which it entered the dry well shield walls, so we can insert tooling.

Since there is no grading to this location, scaffolding was built, and the drain line was cut at this location. The attempt to remove the plug was suspended when it was discovered that the plug was not at the opening into the dry well air gap as expected, but approximately halfway through the dry well shield wall. The sketch shows the approximate location of the plug. Actions are continuing to establish drainage capability from the bottom of the dry well air gap. Slide 4, please.

Boroscope examinations of the exterior of the dry well shell, including at the bottom of the dry well air gap, show no indication of corrosion. The coating is in tact, and in good condition. No obstructions were observed in the dry well air gap that could hold water against the shell. There's no water accumulation at the bottom of the dry well air gap. Slide 8, please.

This photo shows the dry well air gap at azimuth 225, the azimuth of the small reactor cavity leak. It is looking down toward the bottom of the air gap. So, you have the dry well shell on the left, on the right is the bottom -- excuse me, on the right is the concrete shield wall, and in the middle is the bottom of the dry well air gap.

You can see a transition if you -- you should be able to see a transition in between those lines there. That's the transition between the dry well shell and the bottom of the air gap. And then there's the transition between the bottom of the air gap and the shield wall.

MEMBER ARMIJO: And J24, does that relate to a penetration?

MR. STAVELY: Yes.

MEMBER ARMIJO: So, that's just the location of where the penetration --

MR. STAVELY: Correct. It's in the same group of six penetrations, that includes J13.

Slide 9, please. This photo is a closer look at the bottom of the air gap, again at azimuth 225. Again, look at the coating on the left. That's the dry well shell. The coating is in tact and in good condition. There's no signs of corrosion. And on the right you have the concrete shield wall and the bottom of the air gap.

CHAIRMAN ABDEL-KHALIK: Is this really an air gap?

MR. STAVELY: Yes.

CHAIRMAN ABDEL-KHALIK: And it shows these specks? What are these specks in the air gap?

MR. STAVELY: In terms of some of the --

CHAIRMAN ABDEL-KHALIK: Colored specks. Right.

MR. STAVELY: It's concrete, and there are -- there may be some instances of some loose material at the very bottom left over from some of the construction. But just some loose materials at the bottom that are reflecting the light. But you can see along -- again, if you look along the left along that very straight line at the junction of the dry well shell and the bottom of the air gap.

CHAIRMAN ABDEL-KHALIK: So, this is sort of a plan view.

MR. STAVELY: Yes.

CHAIRMAN ABDEL-KHALIK: Flat surface.

MR. STAVELY: Correct. So, you have the bottom of the air gap like this, you have the curvature of the shell here, and you have the concrete wall on that side.

MEMBER STETKAR: Just for clarification, Jim, if you go back to what I hope I can say this time, slide 7. We're looking at the point where that arrow says bottom of dry well air gap. Is that correct?

MR. STAVELY: That is correct.

MEMBER STETKAR: So, the discoloration and the spots that you see, indeed, are the concrete at the bottom of that gap.

MR. STAVELY: Correct.

MEMBER STETKAR: Okay.

MR. STAVELY: It's -- go back to that again, John, please. Slide 7. The boroscope right now would be almost at that arrow. At the end of the arrow it says dry well air gap looking down.

MEMBER STETKAR: Yes.

MR. STAVELY: It's not -- the vent line is not in that area, but it's looking down that way.

MEMBER STETKAR: Okay, yes. You're down below the penetration.

MR. STAVELY: Correct. We're below the penetration, and the only thing between us and the air gap is the air.

MEMBER ARMIJO: Could you see anything in the drain line? Were you close enough to take a peek?

MR. STAVELY: There is not a drain line at azimuth 225.

MEMBER ARMIJO: Okay.

MEMBER CORRADINI: You didn't have a chance to look where there might have been one.

MR. STAVELY: We did lower a boroscope at azimuth zero from a penetration P19. It's above the drain line. So, we're lowering it from approximately 94 feet down to the bottom of the air gap, which is

86'11". And we are -- so, you're lowering it on a cable. We were not able to see the opening to the drain, but we're not sure on our azimuthal span as to whether the drain line is there, we just couldn't see it.

MEMBER CORRADINI: And then I asked last time, and you told me, and I don't remember the number. What do you expect to be the outer shell temperature?

MR. STAVELY: On the inside of that compartment at full power it's approximately 95 degrees Fahrenheit.

MEMBER CORRADINI: On the inside.

MR. STAVELY: On the inside. So, you would expect a similar temperature on the outside.

MEMBER CORRADINI: Okay. Thanks.

MR. STAVELY: Sure. Please return to slide 4. We performed approximately 350 ultrasonic thickness measurements of the dry well shell during the 2010 refueling outage.

Although one area showed measured thickness above nominal, one area was below nominal thickness, but above the thickness used in the dry well analysis. It was within construction tolerances.

Boroscope examination of the exterior of this area, those were on the previous slides we were seeing, show that the dry well shell coating is in tact and in good condition. There's no indication of corrosion in that area.

So, stepping back right now from the details and trying to get a big picture of what we're trying to say with this slide, is we visually inspected the exterior of the dry well shell, we inspected the interior of the dry well shell, and we performed ultrasonic thickness measurements of the shell. And we have no indications of corrosion of the dry well shell. Slide 10, please.

I will now describe the commitments associated with the dry well air gap drains. These commitments are documented in our RAI response and revised commitment table.

PSEG Nuclear will establish drainage capability from the bottom of the dry well air gap on or before June 30th, 2015. Prior to establishing drainage capability, PSEG Nuclear will perform the compensatory actions shown on this slide. Boroscope examinations will be used to monitor conditions at the bottom of the air gap. Visual inspections will be used to monitor the small reactor cavity leak, and look for indications of other leaks. Ultrasonic thickness measurements will be used to monitor dry well shell thickness for any indication of corrosion. Slide 11, please.

After establishing draining capability, PSEG Nuclear will perform the actions summarized on this slide. The air gap drains will be monitored daily while the reactor cavity is flooded. Until the small reactor cavity leak is repaired, visual inspections will be used to monitor the leak, and look for indications of other leaks.

For the next three refueling outages, ultrasonic thickness measurements will be performed to confirm no ongoing corrosion, or establish a corrosion rate.

Should we identify any adverse conditions while implementing these actions, they will be documented and addressed in the Corrective Action Program. Slide 12, please.

In summary, the dry well shell is in good condition. Until drainage capability from the bottom of the dry well air gap is established, the dry well shell will be monitored using boroscope examinations, ad ultrasonic thickness measurements.

The small reactor cavity leak in the blocked dry well air gap drain lines are being managed effectively in our Corrective Action Program, and in accordance with our license renewal commitments.

Our Aging Management Programs insure that dry well shell intended functions will be maintained through the period of extended operation.

If there are no further questions, I will turn the presentation over to John Hilditch, who will provide a brief update on low-voltage power cables. John.

MR. HILDITCH: Thank you, Jim. Good morning. My name is John Hilditch. I'm the Lead Electrical Engineer for the Hope Creek License Renewal Project. Slide 14, please.

As part of a review of the Hope Creek E3 Program and our responses to requests for additional information, we added eight low-voltage power cables to the scope of the Hope Creek E3 Program. These cables provide 480-volt power to a service water intake structure, 480-volt motor-controlled centers. These cables are 500 MCM, tri-plexed, unshielded cables rated for 600-volts.

These cables are tested using the insulation resistant test methodology which is the industry accepted non-destructive method for unshielded power cables.

CHAIRMAN ABDEL-KHALIK: Is there an acceptance criterion for test method?

MR. HILDITCH: Yes.

CHAIRMAN ABDEL-KHALIK: And what is that acceptance criterion?

MR. HILDITCH: The acceptance criteria is 100 mega-ohms for no further action.

CHAIRMAN ABDEL-KHALIK: And what is the level of deterioration associated with that acceptance criterion?

MR. HILDITCH: Well, normally new cable that hasn't been aged at all, you will expect it to be in the giga-ohms, so that will be like a two-decade to three-decade deterioration. So, at that point, you would increase your test monitoring frequency, and prepare to replace that cable.

CHAIRMAN ABDEL-KHALIK: And who established that acceptance criteria?

MR. HILDITCH: That's from the industry accepted practices from what we saw, and what we learned from the industry. And EPRI has documented that in a guidance manual.

CHAIRMAN ABDEL-KHALIK: Okay. Thank you.

MR. HILDITCH: You're welcome.

The insulation resistance test results

will be compared with each other, and compared over time. The comparisons will allow us to detect insulation deterioration that could result from possible wet conditions prior to the cable failing. This test is performed every six years in conjunction with their associated motor-control center outages.

Insulation tests that have been performed to date following maintenance on the motor-control centers show that the cables are in good condition.

That concludes my update on low-voltage power cables. I will now turn the meeting over to Paul Davison for closing comments.

MR. DAVISON: Thank you, John. Mr. Chairman and Committee Members, thank you for --

CHAIRMAN ABDEL-KHALIK: Just before we -- you said that these measurements showed the cables are in good condition. What were the results of the tests vis a vis the acceptance criterion?

MR. HILDITCH: The purpose of the tests was a post maintenance test of the motor-control center work itself. When you do these post maintenance tests, the feeder cables are normally left connected to the motor control centers, so what we have is a result saying that the motor control meggers, the insulation resistance were sat. The one or two I have numbers for, they were in the hundreds of mega-ohms.

CHAIRMAN ABDEL-KHALIK: Is there an established frequency for these tests?

MR. HILDITCH: We have established that for six years going forward. Our initial baseline will start this April.

CHAIRMAN ABDEL-KHALIK: Thanks.

MR. DAVISON: Okay. We hope that you found these updates informative and useful. Our goal, as always, is to insure the safe continued operation of Hope Creek through the period of extended operation. Pending any additional questions, this concludes our presentation. Thank you.

MEMBER SCHACK: Any additional questions?

MEMBER POWERS: Well, there was a question in our last discussion on the bellows and the downcomers, and the suppression pool. Did we ever get an answer to that?

MEMBER SCHACK: I thought we did.

MEMBER POWERS: I thought we did, but I can't remember.

MR. SEIBOLD: George Seibold, PSEG Nuclear. The questions were on the bellows that were in the downcomer?

MEMBER POWERS: Right.

MR. SEIBOLD: Or the vent pipes? And I believe the question was on testing. And we told you that those pipes are tested with Appendix J Type A testing which was done in 2009. And after the meeting, we looked up our procedures, and the bellows are also tested Type B testing on a three-year frequency, half of them are done every outage. We've got eight vent pipes, 16 bellows, stainless steel bellows.

MEMBER POWERS: Yes. Okay. Because they're inside, you don't actually inspect them, you just test them for pressure capabilities. Right?

MR. SEIBOLD: Yes. Most of the bellows are inside, have an installed guard which precludes the visual inspection of the stainless steel bellows.

MEMBER POWERS: Okay. That's good. Thank you.

MR. DAVISON: Thank you, George.

MEMBER SCHACK: No further questions? Thank you very much.

MR. DAVISON: Thank you.

MR. HOLIAN: If the Committee is ready, this is Brian Holian, Division Director, License Renewal. I'll complete introductions, and then turn it over to the NRC Staff's presentation. From left to right on the Staff is Abdul Sheikh, Senior Structural Engineer, Division of License Renewal. Abdul and his staff have been pushing this review on the drain lines and other structural issues at Hope Creek throughout the review.

To his left is Cliff Doutt, Senior Electrical Engineer in Division of License Renewal. To his left, Dr. Allen Hiser, our Senior-Level Advisor, Division of License Renewal. Arthur Cunanan is the Project Manager for Hope Creek, and Bennett Brady is the Senior Project Manager that had oversight of both Salem and Hope Creek. I previously introduced a couple of the Branch Chiefs that are here in the audience. Bo Pham is the Branch Chief responsible for both Salem and Hope Creek. I mentioned Tom Koshy sitting in the first row from the Research organization for electrical cables. Next to him is Raj Auluck, Branch Chief from Division of License Renewal for structural and electrical. I'd also like to recognize in the audience Roy Matthews, a Team Leader from Division of Engineering, Electrical Engineering Branch.

Rich Conte, I believe, is on the phone from Region I. I just wanted to highlight that. He's on mute, if he's there. But I wanted to highlight that. One question that came out of the May 12th Committee meeting was whether the Region had had an inspector look at the video tapes taken by the applicant. We had not at that time. That was kind of a late-breaking issue throughout our review.

Since then in the last month, the Region has sent a Senior Inspector out from Rich Conte's group, and they report in our dry run that we had a week ago that the pictures that the licensee presented of that air gap are very representative of what he saw in the video. So, that was accomplished.

MR. CONTE: This is Richard Conte. That's correct. I'm Chief of the Engineering Branch Number One.

MR. HOLIAN: Good. Thank you, Rich. With that, I'll turn it over to Arthur Cunanan.

MR. CUNANAN: Thank you, Brian. Good morning, Chairman and Members of the Committee. I'm pleased to have the opportunity to discuss the Staff's review of the Hope Creek Generating Station's license renewal application review, as documented in the Safety Evaluation Report. Brian has already made the introductions, so I'll get started with the presentation. As always, we are available for questions at any time. Next slide, please.

This slide shows my discussion of the presentation outline. Next slide. The Final SER was issued on March 9th, 2011, and has closed the one open item related to piping and two confirmatory items related to the inaccessible power cables and environmental-assisted fatigue.

Just prior to the Full Committee meeting, the applicant provided the Staff new information regarding the dry well air gap drains. The issue was presented during the ACRS Full Committee meeting on May 12th, 2011. And, at that time, the Staff had also informed the Committee it was considering a license condition to address the issue.

The Staff has since reviewed the additional information provided by the applicant, and revised the discussion of the ASME IWE program, as well as added a discussion about the license condition in the Safety Evaluation Report. The discussion of this issue is on the next slide.

During our conference call on May 9th, 2011, the applicant informed the Staff of new information about the air gap drains when it sent a boroscope through their instrument lines. The Staff had originally accepted the program in the SER based on the assumption that the air gap drains was available. Based on the conference call, the Staff determined that the current configuration of the air gap drains was unknown, and the revision to the SER was necessary.

The applicant has since then submitted a license renewal application supplement on May 19th, 2011, and has revised the program, and provided commitments to remove the resilience -- the reliance on the air gap drains, and to provide enhancements to verify through boroscope and UT examinations the air gap drain was dry. And as Rich Conte had discussed, a person from the Region had viewed the still pictures for the boroscope.

The Staff will also establish a license condition in order to insure that the air gap drains will be cleared, and the dry well can perform its intended function. With the addition of the license condition, the Staff had accepted this program. Next slide.

This slide shows a summary of the license condition that we provided the members through a memo. I would like to note that the period of extended operation for Hope Creek is April 11th, 2026, and the license condition has the applicant establishing drainage on or before 2015.

I would also like to note that monitoring of the J13 and walkdown of the torus room to detect leakage will be done every outage until the reactor cavity leakage is repaired, regardless of the drainage of the air gap drains being established. Next slide.

I'm going to continue on with the testing of the low-voltage power cables, if you don't have any questions about the dry well.

MEMBER ARMIJO: Yes, just a quick question. On your Slide 4 --

MR. CUNANAN: Yes.

MEMBER ARMIJO: You show the potential for trap water going all the way up to the instrumentation lines, or penetrations. That's not consistent with the PSEG figures that indicate --

MR. CUNANAN: We did have a discussion with the applicant. We do believe up to the one-foot mark it would vent through the vent lines. Abdul Sheikh, can you confirm?

MR. SHEIKH: Yes, it's the condition really unknown, whether it's -- it will leak through those big vent lines, or it can stay up, we don't know. The condition is not known, so this is the worst possible scenario, which we have highlighted in our sketch.

MEMBER STETKAR: But worst possible scenario isn't supported by their boroscope views of that particular area. I assume the air gap, indeed, is open circumferentially all the way around the dry well.

DR. HISER: I think the key word is "potential." I mean, if the drains are plugged and water -- if the leak were to increase significantly so that you now get flow down to that --

(Simultaneous speech.)

DR. HISER: That was the point they were trying to make there.

MEMBER STETKAR: Okay.

DR. HISER: That it would not fill up the entire air gap, but there would be points at which it would leak out.

MEMBER STETKAR: But the boroscope views that we saw in PSEG's presentation indicates that this certainly is not the case.

DR. HISER: Yes, that's correct. Has not been the case, and I think Region I, their review of the information verifies, and we agree that it has not trapped water in that area. But there is a potential for it.

MR. SHEIKH: One reason could be that the boroscope was done after the refueling outage, so it depends when -- whether the water evaporated or not. So, we are looking at the worst possible scenario, and that's what we tried to show on the sketch.

MEMBER RAY: Well, the worst possible scenario would be that there's not a uniform communication circumferentially, and that there's locations that haven't been looked at where water is able to pool.

MR. SHEIKH: You are right. So, to cover those eventualities, we have other conditions, like we are doing the UT examination every outage to detect corrosion. We are doing -- they are doing boroscope examination, they're monitoring the leakage. All those conditions and commitments combined together will insure that the dry well integrity is maintained.

MR. CUNANAN: Okay. Thank you, Abdul and Allen. I'll move on to Slide 6.

At the Full Committee meeting on May 12th, the Staff discussed the closure of Confirmatory Item for Inaccessible Power Cables. The applicant responded to the Staff's concerns, and the Staff was satisfied with its response.

Furthermore, the Staff would like to

answer the Committee's questions related to testing of low-voltage power cables. I would like to introduce Cliff Doutt to answer this question.

MR. DOUTT: Hi, my name is Cliff Doutt, as Arthur mentioned. I was one of the electrical reviewers responsible for low-voltage cables at Hope Creek. To answer the question, subsequent to the Full Committee meeting, the ACRS asked a question as to what testing was to be performed on inaccessible low-voltage cable, essentially 480-volt for Hope Creek. And that may be subject to significant moisture, which is GALL AMP 11E3.

The slides show the appropriate test method. Let's back up a little bit. It depends on some cable characteristics, how they're made, construction, shields, voltage, insulation jacket material, the location, installation, including environment, and which would include terms of radius, or whatever we're concerned with, and the gauging mechanism we're looking for.

Hope Creek was using for medium voltage cable, they're using dissipation factor of tan delta. And for low-voltage cable, they're essentially using insulation condition, as insulation resistance testing, which they've already discussed.

The GALL Revision 2 provides recommendation as to existing test techniques that are available, but it doesn't -- and it provides the option, but it doesn't actually specify which test you need to use. It also has an option there, other testing, state-of-the-art at the time of the testing, so this could change depending on what going forward.

MEMBER SCHACK: You do have a Reg Guide.

MR. DOUTT: We'll get to that in a second.

MEMBER SCHACK: You could get to that in a second. Okay.

MR. DOUTT: That's true. GALL states one or more tests may be used to assess the condition of cable insulation, and such that the cable will meet their intended function during the period of extended operation. So, there is an option. And you may, in fact, need to do more than one test depending on what situation you have.

The applicant's choice of the test method for inaccessible low or medium voltage cable is consistent with GALL AMP 11E3. It's also consistent with the Reg Guide, which is both Reg Guide 1.281, which is in concurrence process now. It is also consistent with NUREG/CR-7000, which is -- it discusses condition monitoring for cables in nuclear power plants. It is also consistent with current guidance, as I understand it and is, therefore, acceptable to the Staff.

In conclusion, based on the use of appropriate test methods, and consideration of the applicant's inaccessible cable operating experience which is there have been no failures in medium or low-voltage cable at Hope Creek, and the consistency with GALL AMP 11E3, which we have found it to be consistent, the applicant's aging program is acceptable to the staff. Any questions?

MR. CUNANAN: If there's no further questions, thank you, Cliff. Next slide, please.

In conclusion, the Staff has determined that the requirements of 10 CFR 54.29(a) has been met for the license renewal of Hope Creek Generating Station.

This concludes our presentation. Do you have any additional questions? Thank you very much.

MEMBER SCHACK: Thank you, Mr. Chairman.

CHAIRMAN ABDEL-KHALIK: Thank you. At this time, our schedule calls for us to take a lunch break. We will reconvene at 12:45 when we consider Commission Paper on Level 3 PRA Activities.

(Whereupon, the proceedings went off the record at 11:27:26 a.m., and went back on the record at 12:45:31 p.m.)

CHAIRMAN ABDEL-KHALIK: We're back in session. At this time, we'll move to Item 4 on the agenda, Commission Paper on Level 3 Probabilistic Risk Assessment Activities, and John Stetkar will lead us through that.

MEMBER STETKAR: Thank you, Mr. Chairman. You alert members, you've received yesterday afternoon very late a revised SECY Paper on this topic, and it has substantive revisions to it, so if you've not read that document, please read it because it is much different than what was presented to our Subcommittee, with different recommendations, and it will have a direct bearing on our letter. So, please, please read that. I apologize. I don't know why we didn't either hear about it or receive it until yesterday afternoon, but that's what it is. So, I want to alert the members to --

CHAIRMAN ABDEL-KHALIK: The revision is dated the 7^{th} of June. So, that's presumably when this revision was issued.

MR. HUDSON: When it was finalized, yes.

MEMBER BANERJEE: Can we get a copy, please?

MEMBER ARMIJO: So, the Subcommittee really has --

MEMBER STETKAR: The Subcommittee has not reviewed that document. That's the message to the Full Committee. We will be writing a letter at this Full Committee meeting based on that document, but our Subcommittee has not deliberated on that document per se. So, it -- there's an increased burden on us in our Full Committee deliberations for the letter. And it's a substantive change. It's not just editorial changes.

CHAIRMAN ABDEL-KHALIK: Do we have copies of the slides?

MEMBER SIEBER: This has been revised recently.

MEMBER STETKAR: And I'm hoping that the Staff will provide us a bit of the background in this discussion on the reasons for that change. All of that being said, as a way of introduction, our Subcommittee on PRA has met twice on this topic back in November of last year, and just recently on May 11^{th} of this year to review draft material and the draft version of the SECY Paper, and the enclosures. And today we'll hear from the Staff on important information in whatever today's incarnation of the

SECY Paper is.

With that, Dan.

MR. HUDSON: I shall turn it over to my Division Director, Rich.

MR. CORREIA: Thank you. Rich Correia, Director of Division of Risk Analysis and Research. You captured exactly what I was going to say. Since the May 11th Subcommittee meeting, the paper has changed in what we were going to recommend for the permissions. The options are the same, but for various reasons, and Dan will explain those, we decided to go with a different option.

That's essentially it, and I'll let Dave get into the details. Thank you.

MR. HUDSON: Okay. Well, thank you very much, and good afternoon everyone, Mr. Chairman. It's a pleasure to be here. I've had the opportunity to speak for the Subcommittee on reliability and PRA twice on this topic. It's a pleasure to be here speaking before the Full Committee for the first time ever. Thank you for having me.

We're here to talk about the options for proceeding with future Level 3 Probabilistic Risk Assessment activities. My name is Dan Hudson, and I'm Technical Assistant in the Research Division of Risk

Analysis, and I've been serving as the Project Manager for this Staff initiative for the past year.

The second slide outlines an agenda for discussion this afternoon. We'll get through the introduction and background relatively quickly, talk about a Commission tasking associated with this initiative, and our approach to addressing that tasking.

In response to the Commission tasking, we'll be talking a bit about potential future uses for Level 3 PRAs, and the options that we developed for proceeding with future Level 3 PRAs. And then, finally, we'll get to what you're probably most interested in, and that's our assessment and recommendation for moving forward.

Our objectives for this afternoon are to first discuss with you and to summarize our approach and options for proceeding that we've included in the Commission paper that's going to be submitted next month to the Commission. We also want to answer any questions and welcome any feedback from the ACRS members. And, finally, we discussed earlier, we're hoping to obtain a letter of support from the ACRS for a recommendation for proceeding.

This slide, just to give you a sense for where we are in this process, and how involved our thinking is at this point, outlines our schedule from the initiation of this project in the February 2010 time frame when we briefed the Commission, followed by our Commission tasking in March 2010. And as you can see here, we have interacted with the ACRS here on three occasions throughout our scoping study.

The activities that you can see on this slide are some of our engagement with external stakeholders, and also this past month you'll see that we participated in a briefing of the Chairman's Task Force to develop options for a more holistic risk-informed performance-based regulatory approach.

So, what we're trying to achieve with this initiative, our overall vision is to extract new and improved risk insights to enhance regulatory decision making, and to help focus our limited resources on issues that are most important to public health and safety.

We hope to do this by first incorporating some of the technical advances that have been made since the last NRC-sponsored Level 3 PRAs that were conducted in the late 1980s as part of the NUREG-1150 study. And we'll be talking a little bit more about that later.

We also want to expand the analysis scope beyond the current PRAs, and beyond those last NRC-sponsored Level 3 PRAs to include an assessment of the risk from additional site radiological sources, such as spent fuel and other units on site.

And, finally, we hope to achieve analytical consistency in the assumptions, methods, and level of detail in the different assessments of various hazards associated with nuclear power plant sites so that in the end we can obtain a meaningful comparison of them, and a relative ranking to determine what's really important here.

Let's talk a little about the value of PRA. This might be overly tutorial for some members, hopefully it will be worthwhile. But we like to talk about PRA as a structured analytical process that provides both qualitative insights and quantitative estimates of risk for answering three fundamental questions. And we emphasize the qualitative insights here, because that's important, too, to our initiative.

The three questions are, what can go wrong? It answers this question by identifying various initiating event scenarios that can result in an adverse event, such as core damage, or radioactivity release. It answers the question, how likely is it by estimating the likelihood of these adverse event scenarios. And then, finally, it answers the question, what are the consequences by estimating the consequences of these different scenarios, if they were to happen.

Now, the scope of nuclear power plant PRAs can vary depending on what they're intended use or application is. And on this slide, I've highlighted some of the different factors that need to be considered when looking at a nuclear power plant PRA. For site radiological sources, we obviously have the reactor cores, which is what the traditional nuclear power plant PRAs have focused on, but you can also see that there are some other important sources of radioactivity on the site, such as spent fuel, and radiological waste.

Population exposed to hazards, we can evaluate the health risk to both the offsite population and the onsite population, though traditional nuclear power plant PRAs have focused on the offsite population.

Initiating event hazard groups would include internal hazards, such as internal events, fires, floods, and external hazards, such as the seismic events and other site-specific hazards that you might consider, including high winds or tornadoes, and external flooding, tsunamis, et cetera.

Plant operating states that can be included in the analysis are at power, which is what many of the traditional nuclear power plant PRAs have focused on. But we can also evaluate the risk of accidents that occur on low-power shutdown states. And when I talk about plant operating states, these are states that are used to divide the plant operating cycle into distinct states based on certain characteristics, like reactor power level, the coolant temperature, pressure and level, et cetera.

And then, finally, to get to our point here with Level 3 PRA, the nuclear power plant PRAs can estimate risk metrics at three different levels using sequential analyses, which the output from one level serves as a conditional input to the next. So, traditional Level 1 PRA for a nuclear power plant estimates core damage risk by modeling from initiating event to the onset of core damage or the achievement of a safe state.

A Level 2 PRA would go beyond core damage and take a look at the risk of radioactivity release. And then, finally, a Level 3 PRA, which is the focus of our discussion today, would estimate the health and economic consequences to the offsite pubic by modeling from initiating event all the way out to those offsite radiological consequences.

And different consequence measures that we could be talking about there include the prompt fatalities, latent cancer fatalities, dose at various locations around the site, and we could also take a look at the economic costs associated with some of the mitigative actions, such as land interdiction and decontamination.

MEMBER STETKAR: I was going to ask you, the scope of the Level 3 PRA consequence analysis, make sure I understand it. Obviously, one metric is health impacts. There have been some discussions about the degree to which you're proposing to address other types of societal impacts, if I can call it that.

The current proposal is to address those by, I think what you just mentioned is economic effects from land interdiction and population relocation. Is that correct?

MR. HUDSON: In Option 3, where we're proposing to do a Level 3 PRA, we've identified a number of different risk metrics that could be computed. And from our perspective, to take that additional step is very easy in terms of the added work and the additional cost, because MAX2, the code that we would be using, is capable of making those estimations.

So, from that perspective, it's very easy to compute it. It's an entirely different thing to talk about how we could potentially use that information after the study.

MEMBER RYAN: Wouldn't that be more site-specific kinds of information rather than generic? It would be hard to -- it's hard to think about that over a range of sites and surrounds.

MR. HUDSON: Sure, I think --

MEMBER STETKAR: But this is a site -- I mean, the proposed Option 3 is a specific site.

MR. HUDSON: That's exactly right.

MEMBER STETKAR: It is not a generic PRA.

MR. HUDSON: That's right. We would pick a specific site, and do a PRA on the single site initially.

MEMBER RYAN: I would say the guidance might have to be pretty broad to cover the range of things you could see at that site.

MEMBER STETKAR: This will be a site-specific PRA. I don't think it's envisioned to be a reactor class, or a nuclear industry PRA.

MEMBER SCHACK: Well, I can say you can make the 85th percentile site sort of --

MEMBER STETKAR: I don't think that's the purpose of what they're trying to do.

MR. HUDSON: No, what we're proposing initially is a demonstration, demonstrate our capability to do this at one site, and then we evaluate the need for follow-on studies.

MEMBER BLEY: Dan, I noticed over and over again as you've read this table, which is labeled "Scope of Nuclear Power Plant PRAs," you said we could, or we can do this. Are these all things you're intending to do?

MR. HUDSON: Well, if you'll allow me, when we actually talk about Option 3, you'll see exactly the scope that we're proposing for Option 3, which doesn't necessarily capture everything.

MEMBER BLEY: Well, let me ask you about one part of it then.

MR. HUDSON: Sure.

MEMBER BLEY: You've -- it looks like you're talking of extending it to worker risk, as well as public. Is that true, or not true?

MR. HUDSON: That's not proposed in Option 3.

MEMBER BLEY: It's not. Okay. When you talk about it, if one wanted to do that, I would say you need to -- we've been seeing the fuel cycle facilities, and they're stewing with whether they should do PRAs or ISAs, but they not only look at radiological risk, but they look at chemical risk. Mostly that affects the workers. In some cases, it can go beyond the workers. Most reactor sites it probably doesn't, but your focus is only on radiological risk, and your discussions are that way, as well?

MR. HUDSON: Yes, it is.

MEMBER ARMIJO: And nuclear power plants. Right?

MR. HUDSON: That's right. We're focusing on nuclear power plants for this specific initiative.

MEMBER BLEY: Okay.

MEMBER STETKAR: And, in particular, a currently operating nuclear power plant.

MR. HUDSON: That's right.

MEMBER STETKAR: For Option 3.

MR. STUTZKE: We'll talk about that.

MEMBER STETKAR: Right, when you get

there.

MR. HUDSON: Any other questions? Okay.

All right. On this slide, I identify some of the prior NRC-sponsored studies estimating risk of public from severe reactor accidents. And this list is not intended to be all-inclusive, it's meant to capture some of the key milestones in our history, and focusing specifically on NRC-sponsored studies, and not some of the other studies that have happened outside the NRC. And I have a caveat here, that WASH-740 was not actually a Level 3 PRA study, it was a non-probabilistic consequence study; although, there was some discussion, they speculated at the time what the likelihood of a severe reactor accident might be.

But the point here with this slide is that over time the NRC and before us, the AEC, had periodically sponsored studies, obtained updated estimates of the risk to the public, as PRA technology evolved, and as our operating experience with nuclear power plants evolved, You could see that on this slide it's been a little over 20 years now since the last NRC-sponsored Level 3 PRAs were conducted as part of the NUREG-1150 study.

MEMBER STETKAR: Do you have any knowledge -- unfortunately, I wasn't at the Subcommittee meeting, so if this was discussed during the Subcommittee, do you have any information -- have any of the current licenses performed Level 3 PRAs in the intervening 20 years?

MR. HUDSON: We do know that some Level 3 PRA analyses have been done in support of license renewal applications.

MEMBER STETKAR: Okay.

MR. STUTZKE: Right. Because it's required to do the assessment of severe accident mitigation alternatives, the SAMAs.

MEMBER STETKAR: And people have actually extended their PRAs to formally --

MR. STUTZKE: Right. Generally, what you see there is those are internal event PRAs extended out to Level 3 space.

MEMBER STETKAR: But you got that part out.

MR. STUTZKE: That's right.

MEMBER ARMIJO: How does this relate to the SOARCA work? Is it replacement, is it --

MR. HUDSON: Good question. There's been some healthy discussion among the staff about that. some of the Subcommittee members may recall that at one point we were talking about the possibility of submitting an integrated Commission paper to provide the Commission with recommendations regarding whether and how to proceed with full studies.

To say that this is -- this would not be a replacement of SOARCA because they're very different studies. They have very different objectives. SOARCA is a consequence analysis, and they used a very specific method for identifying sequences that they wanted to examine in detail. Whereas, a Level 3 PRA would be intended to be much more broad, and not necessarily go to the level of detail that SOARCA did.

MEMBER ARMIJO: Not the limiting or worst case sequence.

MR. HUDSON: That's right. SOARCA was intended to take a really close look at what they believed were the most important accident sequences based on core damage frequency, and based on the potential consequences associated with some of the accidents, such as containment bypass events.

MEMBER ARMIJO: Okay.

MEMBER CORRADINI: Can I go -- I'm sorry. Can I go back to before Sam's question to John's? So, is it -- it's not required for license renewal. It's just some of the licensees have opted to do that in their license renewal process going out to a Level 3 for internal events.

MR. STUTZKE: Well, they are required to look at SAMAs.

MEMBER CORRADINI: So, this is a way to do it.

MR. STUTZKE: Right. Because the -- you know, SAMA analysis is, basically, a cost-benefit or value impact study, so you need to estimate the averted risk.

MEMBER CORRADINI: Okay.

MR. STUTZKE: Monetize it.

MEMBER STETKAR: Back to SOARCA, Dan, before you flip the slide.

MR. HUDSON: Yes.

MEMBER STETKAR: It is true, though, however, a lot of the methods advancements and modeling techniques that were developed under SOARCA should directly integrate into the Level 2-Level 3 PRA analyses. Isn't that correct?

MR. HUDSON: I would agree with that, and the two levels --

MEMBER STETKAR: They're certainly not purely parallel efforts.

MEMBER ARMIJO: Yes.

MR. HUDSON: But the advancements that

have been made with MELCOR and MAX, or the demonstration of that capability is something that would definitely transfer over to a Level 3 PRA.

MEMBER CORRADINI: And in the discussion of your Options 1, 2, and 3, you integrate -- you considered that in terms of time savings or funding savings, I assume.

MR. HUDSON: You'll see when we talk about Option 3 and the site selection considerations that there are some factors related to the SOARCA project that would come into play there.

MEMBER CORRADINI: Right. Okay. The reason I asked the question the way I did is, I thought John was going this way, maybe not. Is that given SOARCA, or Sam, given SOARCA things have been done that you don't have to redo. So, it's not a matter of starting from a blank sheet of paper.

MR. HUDSON: That's right.

MEMBER STETKAR: It may not be redo, but at least relearn, or reinvent.

MR. HUDSON: Right.

MEMBER CORRADINI: Okay.

MEMBER ARMIJO: In the Level 3 PRA offsite radiological consequences, are you constrained to evaluate those consequences using one rule, LNT, or is that on the table as what you think is more realistic, or is there a policy decision that you have to follow?

MR. HUDSON: Marty, do you want to tackle that?

MR. STUTZKE: Well, I think we would start out, and probably just what the Commission directed SOARCA to use, which was LNT, plus some various threshold sensitivity studies.

MEMBER ARMIJO: There would be sensitivity studies?

MR. STUTZKE: Right.

MEMBER ARMIJO: Okay.

MR. STUTZKE: I mean, part of the problem is we're trying to build the model right now just to get something up and working with the idea that in the future then we could really see the difference between an LNT model versus various sorts of threshold models like that. To try to do all of it in one study is pretty large amount of work to get done at one time. Our fixation now is on trying to build a nice integrated logic model that covers all the sequences in some reasonable quantification time.

MR. COE: Mr. Chairman.

CHAIRMAN ABDEL-KHALIK: Yes.

MR. COE: If I may add one additional

comment to the question regarding SOARCA. I'm Doug Coe, I'm the Deputy Division Director, Division of Risk Analysis Research.

One way to look at the relationship between SOARCA and the Level 3 PRA is that SOARCA started with a selection of accident sequences from a PRA. That particular PRA is not as -- does not have the scope of the PRA that we are talking about now. So, the sequences that they've examined for a particular -- for a couple of particular sites are -- in fact, will be documented, and will be available for our use.

However, if our Level 3 PRA were to generate additional sequences from the expanded scope that rise to potentially equally or greater potential significance or importance, then that would suggest it might be worth using the SOARCA tools to study those sequences, as well. So, the whole -- the relationship becomes something of an iterative one, where the PRA helps you decide what could be important, and for those things that you think are important, the SOARCA tools, such as the MELCOR and MAX tool can be used to further examine in a very detailed way those sequences that we think are important. That knowledge can then be recycled back into making a better PRA.

MEMBER STETKAR: Thanks, Doug.

MR. HUDSON: Okay. So, let's talk a little bit about why the Staff proposed moving forward with Level 3 PRA activities. The first reason, as I alluded to in our overall vision, is that there have been a number of technical advances since the NUREG-1150 study was conducted. Some examples include modifications that have been made to enhance nuclear power plant safety and security. This came about by way of developing and implementing various risk-informed regulations, such as the Station Blackout Rule and the Maintenance Rule. There's also been improvement to training and maintenance practices. And we've also had the development of severe accident management guidelines, or SAMGs, and the implementation of the extensive damage mitigation guidelines, or B5B measures, that were implemented following the attacks on September 11th.

Other advances would fall under the realm of our improved understanding and modeling of severe accident phenomenology as a result of extensive research programs. And then, finally, a related advancement has been in the area of PRA technology where when I say PRA technology, I'm talking about PRA methods, models, tools, and data. So, we have acquired a lot more data as a result of operating experience over the years, and we've also had some advances in technology as information technology and computing capability have evolved over the years.

In addition to this, as we talked about on the first slide, there are some additional scope considerations that we would intend to address through new Level 3 PRAs, and we'll talk a little bit more about that in the next couple of slides.

On this slide you'll see the reactor accident risk cube, as conceptualized by Marty back at the beginning of this project. And what we're trying to illustrate here are the different dimensions of PRA that analyzes the risk of accidents involving the reactor only. And you could see that we considered various plant operating states, PRA end states, and initiating event hazards that correlate very well with the table that I showed you earlier that showed how the scope of nuclear power plant PRAs can vary.

What's illustrated here by the green and yellow shaded region is the approximate scope of the NUREG-1150 PRAs. And you'll see that when looking at reactor accidents, they were focused primarily on single unit reactor accidents occurring during full power operations that were initiated primarily by internal events. There was some treatment of internal fires and seismic events for two of the plants that were analyzed.

MEMBER POWERS: Is there something telling about this cube that it lacks perspective?

MEMBER CORRADINI: Don't answer that question.

MEMBER ARMIJO: I think it's a darn nice cube.

MEMBER CORRADINI: Don't answer that question.

MEMBER STETKAR: Next slide.

MEMBER ARMIJO: I think it's a good-looking cube. It's a small cube. It doesn't need perspective.

MR. DAVISON: I couldn't resist, Marty.

MR. STUTZKE: I understand.

(Laughter.)

MR. STUTZKE: I think my wife said the same thing when she saw it.

MR. HUDSON: And, again, with this initiative, as we've already alluded to, we're looking at expanding the scope beyond just reactor accidents. If you want to be more complete in taking a look at a nuclear power plant site, we should be considering the risk of accidents involving some of the other site radiological sources, such as spent fuel and radiological waste.

MEMBER POWERS: One of the characteristics of both 1400 and NUREG-1150 is that they considered an accident at a unit on the site, and really gave less than I would say comprehensive examination to what happens to Unit 2 through 4 on the site.

MR. HUDSON: That's right.

MEMBER POWERS: Isn't it -- in light of the recent events in Japan, is it not time to change that perspective?

MR. HUDSON: That's something that we're hoping to capture with this initiative, as well. And you'll see there, again we're trying to put things in perspective with NUREG-1150. The approximate scope of NUREG-1150 is captured by that blue shaded region on this diagram. And, as you can see, it was focused on single units. But what we're hoping to achieve here is a much broader perspective by taking a look at accidents that could involve multiple units at the same time.

MR. STUTZKE: Yes. For example, when one looks at seismic risk, what people normally think about is shaking the plant, so individual units get into trouble. But one of the things that's occurred to us is we might be modeling seismic failures we don't normally think about, like doorways, and stairwells, and things that control operator accessibility.

Then there's issues where one unit gets in trouble and we know that the radiation field is so high that operators are precluded from going. So, ideally, we're try to go after all these things.

MEMBER STETKAR: Well, it's not just restricted to recent events, seismic events or flooding, or strictly external events, because there are a number of operating units that substantially share support systems, electric power --

MR. STUTZKE: Yes.

MEMBER STETKAR: -- cooling water systems, such that even certain classes of traditional internal initiating events could have multiple unit impacts, or certainly affect the resources available to the second unit, because if you only have one diesel shared between two units it has to go one way or the other.

MR. STUTZKE: Yes, when we were first conceptualizing the project, I was making statements like I want to know the risk when Unit 1 is operating full power, Unit 2 is in shutdown with the reactor vessel head removed, and there's fuel movement in progress.

MEMBER STETKAR: Right.

MR. STUTZKE: Or any other combination in between.

MEMBER STETKAR: And the Unit 2 tech specs allow you to have a couple of diesel generators out of service --

MR. STUTZKE: Exactly.

MEMBER STETKAR: -- that Unit 1 might have taken credit for --

MR. STUTZKE: But the electric power system is interlaced.

MEMBER STETKAR: Exactly. Exactly.

MR. STUTZKE: That was the intended scope.

MR. HUDSON: Any other questions on this slide?

So, based on all these factors that we've been discussing up until now, the Staff at a Commission meeting back in February 2010 proposed to the Commission that we move forward with new Level 3 PRA activities. So, in response the Commission tasked us by way of a Staff Requirements Memorandum that provided conditional support for our activities, and directed us to continue our internal coordination efforts, and engage external stakeholders in formulating a plan and scope of future actions.

They also tasked us with providing them with various options for proceeding, which included costs and perspectives on future uses for Level 3 PRAs.

So, to respond to this Commission tasking, the Staff developed a three-phased approach for developing options. The first phase consists of a scoping study that we've been conducting since the April 2010 time frame, and that will conclude upon submission of the Commission Paper to the Commission. Phase 2 would consist of whichever option the Commission ultimately directs the Staff to proceed with. And then Phase 3 would consist of any follow-on activities that would, obviously, be dependent upon what Phase 2 consisted of. But you'll see, as I note, that both Phases 2 and 3 do require further Commission direction.

Again, in trying to be responsive to our Commission tasking, the Staff developed a number of objectives for the scoping study. The first was to identify potential future uses for Level 3 PRAs. The second was to develop various options for proceeding that vary depending on the scope of the analysis, the

PRA technology that could be used, site selection considerations. And this is an important point, we'll talk about this a little bit later, but you'll note that one of our objectives of the scoping study was not to select a specific site at this point. We're developing a number of options, some of which don't include proceeding with the Level 3 PRA, so we didn't really want to try to engage with industry at this point without having full Commission support for proceeding with a Level 3 PRA. We also wanted to identify various resource estimates for these options.

MEMBER CORRADINI: But to carry it out, you'd pick a site.

MR. HUDSON: That's right. Yes, if Option 3 were selected, or any other option that the Commission directed us to proceed with that involved performing a PRA study, we'd have to engage with industry to select a site.

MEMBER ARMIJO: So, you'd come up with some selection criteria for the site, multiple units.

MR. HUDSON: That's right.

MEMBER ARMIJO: Okay.

MR. HUDSON: We'll talk a little bit more about the different site selection considerations for Option 3 in a little bit.

We also wanted to determine the feasibility of different options. You'll see that we narrowed our ultimate list down to three options. Wanted to obtain external stakeholder views, so we engaged in a variety of activities to do so. And then, finally, we wanted to identify a Staff's recommendation for proceeding.

MEMBER BLEY: I wonder if you've thought any more about something you talked about at the Subcommittee meeting. Clearly, you're going to work with a utility, and a power plant, but will this be an NRC study at power plant, or will it be some kind of joint EPRI/NRC project, or some other industry organization? Have you worked that out?

MR. HUDSON: I wouldn't say that that's something that's been worked out at this point. There have certainly been more discussions on that topic. I know that at our public meeting, we engaged with EPRI there, and we talked about the possibility of a Memorandum of Understanding to in some way share some of the workload here. There's a number things that have to be -- to be considered there. And one of the concerns we had initially when thinking about some of the options that would involve much more cooperation with industry or shared responsibility, and this is the potential public perception of our lack of independence in this effort. So, a lot of things have to be considered when we contemplate that possibility.

MEMBER BLEY: Okay.

MR. HUDSON: Some of the activities that we've been engaged in over the past year include internal coordination activities, such as various workshops, coordination and alignment meetings, and briefings. I talked about a briefing for the Task Force that we participated in at the end of last month.

External stakeholder engagement activities included our interactions with you, presentations at the Regulatory Information Conference in both 2010 and 2011. And then, finally, the Category 2 Public Meeting that we held on April 11th, that included participants from a variety of organizations; representatives from NEI, EPRI, ECS, public media, research organizations, and vendors were there.

MEMBER STETKAR: Dan, at that public meeting did you present the three options, and did you get any feedback?

MR. HUDSON: We did. Actually, at the time we had four options, so we presented four options at that meeting. And we've since gone down to three, but we did lay out the different options that were being considered, and what our current thinking was at the time.

MEMBER STETKAR: Okay.

MR. HUDSON: The overall response was positive. People saw the value of this initiative, but expressed some concerns about the comprehensiveness of it, the scope and our ability to complete such a study in a relatively short period of time, such as --

MEMBER CORRADINI: So, they thought you were going too fast with not enough resources?

MR. HUDSON: Yes. Well, they also --

MEMBER CORRADINI: Who is the "they?" Did you say who the "they" was?

MR. HUDSON: We had representatives from NEI, EPRI, ESC, vendors. I think we had a utility representative participating by teleconference. But, yes, the concern was when you take a look at the scope, and all the different factors that we're trying to consider with this initiative, people expressed some concern about where do you draw the line? How are you going to wrap your arms around this and make it a manageable problem?

MEMBER ARMIJO: Dan, going back to that previous slide, can you really do this thing first-class job without industry, without a reactor owner, a site, and --

MR. HUDSON: That's a good question. I mean, to be clear, I don't think we would intend to do it without them. I think to do this would definitely require some cooperation and collaboration with industry. It's just a matter of the extent of that cooperation and collaboration. They would, obviously, have to provide us with information to do the study.

But to get to another point that you made, you talked about this as a first-class study.

MEMBER ARMIJO: Yes, don't do it unless it's going to be first-class.

MEMBER CORRADINI: Well, maybe just to provocative, I mean, you don't have to buy a Cadillac to get from Point A to Point B. You could go there in a Chevy or a Ford, so I'm trying to understand -- I'm still trying to understand the context of too much too quickly. Is it because they wanted -- that you were aiming for --

MR. HUDSON: I think it was just when you start talking about the different scenarios, and we'll talk a little bit later about the possibility of evaluating consequential multiple initiating event scenarios, the number of different possible combinations that you could be looking at is almost innumerable. So, that's the concern, is making those decisions about where you draw the line, how you capture this problem and move forward, and get something like this done in a reasonable time frame, not taking 10 years to get the project done. Those were the sorts of concerns that were expressed.

MEMBER CORRADINI: Thank you.

MR. HUDSON: Okay. You might recall from our Commission tasking that we were asked to provide some perspectives on future uses. So, as part of the scoping study we identified a number of potential future uses for Level 3 PRAs. And we did this by first taking a look at how the NUREG-1150 PRAs were used, and we also wanted to take a look at our existing risk-informed regulatory framework and see where maybe we could make some enhancements.

One caveat for this slide I should point out, because there's been some confusion about this in the past. This list is really intended to apply to future Level 3 PRAs, in general, and it's not meant to apply specifically to the Level 3 PRA that we proposed in Option 3, because ultimate use would be very closely linked to the scope that we decide upon.

So, one potential future use was to assess or confirm the acceptability of our current use of PRA and regulatory decision making. And some examples of this might be the use of limited scope PRAs to support Regulatory Guide 1.174 applications, the use of acceptance guidelines that are based on reactor-specific risk metrics, such as core damage frequency and large early release frequency, things like that.

Another use could be to verify or update regulatory requirements and guidance, and here we're focusing more on those that are based on NUREG-1150 information. Getting back to Regulatory Guide 1.174, the Staff used some NUREG-1150 information to show the acceptability of the CDF and LERF acceptance guidelines.

Another topic that's come up throughout our interactions has been the regulatory analysis guidelines, and the technical evaluation handbook that the staff uses to conduct cost-benefit or value impact analyses. Some of that information was NUREG-1150 information, so there's another good example of something that we could potentially update as part of this effort.

Future Level 3 PRAs could also be used to support specific risk-informed regulatory applications. And one example here is providing the technical basis for risk-informing emergency preparedness, for example, or risk-informing spent fuel storage and handling, or siting when we talk about the multi-unit aspects.

Could also develop and pilot-test PRA technology, standards, and guidance to insure that the requirements, as part of this effort, are clear, understandable, and that they ultimately result in consistency. And like the intended use of the NUREG-1150 PRAs, future Level 3 PRAs could be used to prioritize generic issues and nuclear safety research programs. Could be used to support PRA knowledge management and risk communication activities.

What we're talking about here is, obviously, there is going to be a training component for the individuals that would participate in this initiative to develop new Level 3 PRAs. We could use information to update the training materials for risk analysts. And when we talk about risk communication activities, the idea here is that as we develop new Level 3 PRAs, we would have a more comprehensive toolbox to work with. And that could be used to inform the public on what issues are really most important to pubic health and safety here, so it could support risk communication activities.

And then, finally, future Level 3 PRAs could be used to support future risk-informed licensing in new and advanced reactor designs. And one example I think of here is the technology-neutral framework that was proposed in NUREG-1860. This framework that could be used to develop alternatives to 10 CFR Part 50 for licensing requires a full scope Level 3 PRA to develop a frequency consequence curve. So, future Level 3 PRAs could be used to pilot-test that framework.

MEMBER STETKAR: Dan, before you leave this one, the second bullet up from the bottom about PRA knowledge management, or knowledge transfer, or knowledge development even, just don't want to discount that too much, because I suspect that a rather small fraction of the current Staff, Marty perhaps being an exception, but he wasn't on the Staff at that time, were actually around 20 years ago when the 1150 studies were done. And regardless of how much you really think you know from sitting back and looking at other studies that were developed by other people, you really don't know much about PRA until you do something. So, just strictly the exercise of being involved in one of these studies is an extremely valuable learning experience. And if we only do these sort of once every generation of analysts, keeping that firsthand knowledge alive before people retire is pretty important. So, notwithstanding all of the other benefits that you've listed here, that is, I think, really valuable, because eventually some of the old gray hairs are going to retire, and that firsthand experience and knowledge will be gone.

MEMBER POWERS: That's a promise?

MEMBER STETKAR: I'm not gray yet.

(Laughter.)

MEMBER STETKAR: I was going to say balding people, but that was just hoping too much.

MR. STUTZKE: No, I appreciate what you're saying. Since I've been at the Agency for almost eight years now, and we've always been looking for risk analysts that have actually done the work.

MEMBER STETKAR: That's right.

MR. STUTZKE: And they're hard to find.

MEMBER STETKAR: As you know, it's different.

MR. STUTZKE: The other part I would emphasize in this knowledge management goes into what we were calling 21st Century PRA Documentation. The idea that it's not big monolithic books, you know, or files. We were going to try to be clever and sort things out, so you could access the information but try to capture the decision process; why didn't you model it like this? Well, I told the boss it would cost X dollars, and he said no, or we went to the ACRS and they said go do this. But I wanted to capture that thought of how the model -- because, as you all know, two, three years you don't remember that's why you ended up with what you did.

MEMBER ARMIJO: Like a design basis.

MEMBER STETKAR: And that's not a generic "you."

MR. STUTZKE: You're right.

MEMBER STETKAR: Two or three years, I don't remember what I did.

MR. STUTZKE: Yes. So, we thought about that extensively, and there's some very good software tools I think that would help us that way.

MEMBER STETKAR: And the software tools actually enhance that documentation process.

MR. STUTZKE: Yes.

MEMBER STETKAR: It's a lot easier than it was 20 years ago.

MR. STUTZKE: Oh, yes.

MEMBER STETKAR: To simply sit and jot some notes down and some key words, to capture that thought than it was 20 years ago.

MR. HUDSON: I recall that there were at least a couple of Commissioners at the original Commission meeting back in February 2010 that expressed interest in this training and knowledge management aspect.

MEMBER CORRADINI: Only two?

MR. HUDSON: Well, I think there were only three, actually, at the time, so two out of three ain't bad. Right?

MEMBER CORRADINI: Yes. I guess, John is being somewhat polite. I personally think that's probably the most important reason. If you guys don't maintain this capability, who's going to maintain it? And from the standpoint of purely confirmatory, I wouldn't expect the industry to come back and train you all.

MR. HUDSON: Appreciate that perspective.

MR. STUTZKE: As much as they would like to sometimes.

MEMBER STETKAR: Occasionally, industry comes, though, and becomes one of us.

MR. HUDSON: Okay. So, moving on to the section that we're probably most interested in talking about today. The Staff, ultimately, developed and included three options in the Commission Paper. And, as I said, as part of the scoping study we considered a number of different options, some that were limited in scope, some that took a look at new and advanced reactor designs, but ultimately we arrived at three options that we believed were the most feasible from a cost-benefit perspective. And we'll talk more about each one of these in detail.

The first option was to maintain status quo. This is otherwise known as the do nothing extra option. And when we talk about maintaining the status quo, that would be continuing our evolutionary development of PRA technology based on our available resources. And this is driven primarily right now by our user need request program with the program offices. And we also have an agency long-term research program where we take a look into the future five to ten years and try to anticipate what our regulatory needs are going to be. And there's a process in place for the Staff to propose essentially one-year scoping studies to explore some issues in detail, and determine whether or not it's worth investigating that further.

An obvious advantage here, and you'll see on these upcoming slides, I have advantages and disadvantages listed here. And what I'm really talking about are the relative advantages and disadvantages when comparing the different options.

An advantage of this option is that it's consistent with our fiscal climate. It allows us to focus our limited resources that we have, which are continuing to decline as we talk about a flat budget, and what that really means is that there's less money available to support technical work. So, our resources are actually starting to decline over these next couple of years. So, this option allows us to continue to focus those resources on the mission critical work that we're doing right now.

Disadvantages are that the insights that we're hoping to obtain from performing a new and more comprehensive Level 3 PRA would not be realized. We're making a decision with Option 1 that this initiative is not worth pursuing at this point. We're happy with the status quo, and so we're not going to realize the benefits of doing a new Level 3 PRA.

A disadvantage is that this can result in potentially inconsistent and more costly treatment of issues that come up in the future, because we would be developing the necessary PRA technology on an ad hoc basis, rather than trying to devote some resources right now to develop a toolbox of sorts that would better enable us to address issues using a more integrated perspective.

Option 2 involves conducting focused research to address some of the gaps that we're aware of in existing PRA technology prior to performing a new Level 3 PRA.

When I talk about the technical gaps, these gaps are really related to the expansion of the scope that we're looking at when talking about multi-unit risk, and the risk of accidents involving other radiological sources, such as spent fuel. And the gaps are also related to the differing degrees of sophistication that exists right now when assessing the risk of various hazards. So, the idea here is that we need to fill in these gaps associated with expanding our scope, and also to try to level the playing field when taking a look at internal events, and various external events.

You'll see here that we have identified some research areas that we think are worth exploring over the next couple of years. The modeling of consequential multiple initiating events, as you might imagine, this one came out after the event in Japan. And what we're talking about here are events that are closely linked in time from the perspective of the mission time that you would be considering for a PRA. The example of the seismic-induced tsunami is a good example, or seismic-induced external flooding. These are the sorts of things that come into mind, but they're not really considered in our current PRAs.

Modeling of multi-unit dependencies. We've talked about this already when talking about the different dependencies that exist through shared support systems. HRA, we know that --

MEMBER RAY: Can I ask a question?

MR. HUDSON: Sure.

MEMBER RAY: Because it puzzles me, I may as well ask. Why is a flooding event not a single event? You seem to have considered it a multiple event. In other words, why wouldn't the consequences of flooding be a single event?

MR. HUDSON: What we're talking about here is not flooding in isolation. We're talking about flooding that occurs very close in time after another event that has already challenged the plant in some way.

MEMBER RAY: Okay. I guess I'm thinking whether the plant had or had not been challenged, a flooding event could lead to station blackout, for example.

MR. HUDSON: Sure.

MR. STUTZKE: But you could hypothesize, for example, an earthquake that damages some of the equipment.

MEMBER RAY: Yes, of course.

MR. STUTZKE: Creates the flood against the rest of it.

MEMBER RAY: No, no. I was just thinking about station blackout due to flooding. In all my experience around here, the assumption has just sort of arbitrarily been made that that mechanism didn't exist, at least I've never heard --

MEMBER STETKAR: Give you another example, a fire-induced internal flooding event, because all of the sprinkler systems come on and flood the basement of Building X. That's a little -- but that's akin to that first bullet, also. To take it out of the perspective of Fukushima and tsunamis, if you will.

MR. STUTZKE: Well, shortly after the Fukushima event, I got asked questions like how do you consider the after-shocks in your seismic PRAs? We don't.

MEMBER STETKAR: Which is a correct answer.

MEMBER POWERS: But he answered.

MEMBER STETKAR: A consultant's answer would be not very well, but --

MR. STUTZKE: And having to talk about that for a day, it's like that might be difficult.

MEMBER BLEY: I have a little problem with Option 2, and my problem is these were all things -- the spent fuel technology, I mean, you could do a spent fuel PRA, focus on that. And if these were running some experiments to test something out or developing a new theory, that's one thing. But all of those except the spent fuel one are things that to advance the state-of-the-art you almost have to do them within the context of a PRA. And if you're not doing the PRA, how do you do them?

MR. HUDSON: That's a good question, and a good point. But I think in the HRA area, for example, I think that you could explore methodological development, for example, for a post core damage HRA. How we would model the SAMGs and EDMGs, for example, talk about that as kind of an interesting problem, because the typical success/failure paradigm that we use with human failure events might not apply so well in that space.

MEMBER BLEY: But they're going to be

heavily dependent on dependencies of all sorts that exist, and without the scenarios that lead to that point I'm questioning --

MR. STUTZKE: No, I would agree, the most you would get out of that sort of thing is you would get some sort of procedure that says well, we think you need to model it like this, and look for that. And here's how to estimate the likelihoods.

MEMBER POWERS: The one that strikes me is -- would figure into my thinking about Option 2 the most, just from my perspective, is that any attempt to redo 1150 is going to have to treat both boiling water reactors and PWRs kind of inevitably. And the fact is that from TMI we gained a tremendous qualitative insight on how PWRs behave under severe accident conditions.

We have no similar technology for BWRs, and we have a very weak separate effects test even in-pile testing on BWRs. Now, we have three really good data points that have the capability of giving us the same kind of information maybe qualitative that we got out of TMI. And I might want to carry that to fruition before I undertook this PRA effort just to get BWRs and PWRs on the same technical foundation.

Because right now, the people who invented the BWR Core Models did the best they can, but they were operating with a very, very weak, weak relative even to the PWR database, because of the peculiar nature of BWR cores, and the channel box kind of design, they're hard to simulate in out-of-pile experiments; whereas, PWRs can be done fairly easily and qualitatively. And it seems to me that that unequal footing would emerge in my mind very strongly since I'm on the cusp of being able to reverse that, and get them on an equal technological footing.

MR. HUDSON: Another thing I think about here, and to your point about needing to do this within the context of the PRA, we do have an ongoing SPAR model development program that we're trying to expand upon and improve the current SPAR models that we have. So, one way that we could approach is to take a look at some of the existing SPAR models, and try to do this work within the context of one of them.

MEMBER STETKAR: Mike, did you have something?

MEMBER CORRADINI: Well, I guess I had a third type of question. So, I guess I was thinking the same way that Dennis was, but I've never done one of these, so I figured you're going to start with something that's completed. So, with any of those bullets, are you going to start with a Level 3 PRA and add on to it by doing some of this?

MR. HUDSON: No. I don't think we've be looking at a Level 3 PRA --

MEMBER CORRADINI: No, but maybe I didn't make myself clear. I'm saying is there enough QA in your past endeavor of 20 years ago in NUREG-1150, you pick up one of those and add on to that?

MR. HUDSON: I don't -- perhaps Marty can expand upon that, but I don't believe that we have the capability to do that with NUREG-1150 PRAs.

MR. STUTZKE: No.

MEMBER BLEY: I would think if you showed -- you have as a backup the slide that you showed us at the Subcommittee meeting on the choices of plants?

MR. HUDSON: No, I didn't include that slide this time around, but --

MEMBER BLEY: Oh, too bad.

MEMBER STETKAR: You don't have that to pull up?

MEMBER CORRADINI: I mean, just so you see where I'm going to, is I was thinking of what Dennis asked and what Dana asked, it seemed to me I can think of a couple of candidates that fit in NUREG-1150 and are a BWR that might be the thing I might go after.

MR. COE: If I could add just one thing. Purposefully, Option 2 was left without that kind of specificity to give the Staff some flexibility. Obviously, we would be smart about how we develop the modeling methods to address those gaps. It might be possible to use a single site, it might not. We're not holding ourselves to a single site. And the objective at the end of Option 2 in about three years is to be prepositioned and able to go back to the Commission and say we're ready now to select a site, because we know what we need to do, and we have confidence that we can do it.

So, Option 2 would be a smart approach, but it would be a more extended time frame, which is consistent with current budget environment.

MEMBER STETKAR: Dan or Doug, one of you two, something I was going to ask, that if I'm a marketing person, that first bullet under "Potential Objectives" is a very strong marketing statement. "Insure important technical gaps are closed," have finality before I develop a full scope Level 3 PRA. How do you address the comment that we've been struggling with issues of how does one do HRA, and how does one an uncertainty analysis from more than 20 years and still have not yet reached closure? How are we going to reach closure on those issues in the next two years, or is this simply an open-ended research so that when we recognize we don't reach closure yet, we still don't have that finality, we still can't do a Level 3 PRA, because we don't know everything.

MR. HUDSON: Yes, that's a really good point. We need to be careful with --

MEMBER STETKAR: Because we're still struggling with issues that were raised 30 years ago, and haven't reached closure.

MR. HUDSON: We don't want to set ourselves up for failure.

MEMBER STETKAR: But that's a marketing point that in terms of we're going to reach closure on these issues before we do the Level 3 PRA, so that, as Doug mentioned, we have finality. Now we really know how to do it. That's my concern in this, is that at the end of two or three years we discover that well, we really haven't closed any of those bullets under scope, so we need to continue the research until we reach closure.

MEMBER CORRADINI: Well, I guess I'm kind of with John on this. It seems to me that until you try to do it, you don't know what you don't know. I mean, you think you do, and you can tell me that anyone -- the way you answered Dennis is one of those five bullets you said well, we'll develop a procedure to do it. We won't do it, we'll just be ready to do it with a procedure. And it seems to me I'd rather take the exact opposite approach, pick a plant, pick a site, start doing the Level 3 PRA, and if something here is a real tough nut, okay, that's the tough nut. Maybe we're not going to do that one right away. We're going to proceed down a different path, and then you start building a whole -- the whole event, or the whole technology at least in the current thing, and document it with all these fine tools that you say you have.

MEMBER BLEY: I could write a procedure today but it's when you start trying to actually do it that you run into --

MEMBER CORRADINI: Yes. And I guess I'm still very -- it was interesting what Dana said relative to the BWR. I hadn't thought about it this way, but this might be an interesting way in my mind to justify actually going to a complete analysis of a particular type just to see what you would learn.

MEMBER STETKAR: One of the forcing functions of actually doing a risk assessment is when you come to tough nuts, if you have the discipline, you don't set it aside and say we're going to get to it later. You at least try to solve the problem.

MEMBER CORRADINI: Try to attack it.

MEMBER STETKAR: Document what you did, this is the best that we could do today. Perhaps the results are not all that sensitive to various ways of doing it, but at least you made decisions about how to do it. You've been forced to make those decisions rather than diving other procedures that might be tested. Anyway, that's --

MR. HUDSON: Yes. Maybe we'll revisit this as we start talking about Option 3. But I think when the Staff is recommending Option 3 all of these points that you're making are cases that we were making to support moving forward with that option.

MEMBER STETKAR: Well, I think the wording in the first bullet up there has changed a little bit under Option 2 in terms of --

MR. HUDSON: You're right.

MEMBER STETKAR: -- the way I characterize them in terms of marketing.

MR. HUDSON: Yes, that wording has changed, and we need to be careful about that because we want to make sure that we're successful.

MEMBER STETKAR: This does instill a note of finality within a very well-defined time period.

MR. COE: And that's such an important point, if I may just add one final thought to that. We have to be careful, as Dana indicated, with our language. There is no -- we're not shooting for any particular standard. And I don't know of any particular standard that would be meaningful for this project other than it meeting its objectives, which is that it works to provide us with risk insights that we otherwise would not have had.

At the end point, whatever model comes out of this project, if one was to come out of this project, it will be an evolutionary process that would proceed even after that point, and continue improvement over time. So, we're -- sometimes we think of this as aligning at some gold-plate standard, and that is a concept we're trying not to convey to people.

MEMBER POWERS: Well, I think it would surprising if you undertook this effort and it didn't become the standard, because that's certainly the case of WASH-1400, the case of 1150. How can it not be the standard?

MEMBER CORRADINI: I agree. If you think back at WASH-1400, a lot of stuff they did was very crude, but at least they did it in a very proceduralized -- so you could follow exactly how all the things fit together.

MEMBER STETKAR: Well, but there's still people who refer back to WASH-1400 and said they did it this way so, therefore, that's the way it shall be done in the sense of a de facto standard.

MEMBER BLEY: And the language came out.

MEMBER STETKAR: Yes. Try to define what an external event is to people who weren't there.

MEMBER POWERS: Why is fire an external event?

MEMBER STETKAR: Because it wasn't --

(Laughter.)

MR. HUDSON: Okay. Let's talk about some of the advantages and disadvantages of this option. The first advantage is that it acknowledges the challenges that we're faced with right now with our current budget climate, while still allowing us to make progress towards performing a new and more comprehensive site Level 3 PRA. It focuses the limited available resource that we have on our existing mission-critical work, much in the same way that Option 1 does. And it focuses the additional resources that have already been requested on needed research to fill in gaps.

It's been talked about here, but the idea here is that we would be enhancing our PRA capability by advancing the state-of-the-art in some of these very specific technical areas. And, finally, it will enable better understanding of the potential resource implications of related efforts before committing substantial resources to supporting a new Level 3 PRA.

And when I talk about the related efforts, I'm referring to the Chairman's Task Force to develop options for a more holistic risk-informed and performance-based regulatory approach. And as you're probably all aware, we had the near-term and long-term task forces associated with the event in Japan. So, there are going to be recommendations coming from each of those task forces, and we don't really know what those are at this point. So, selecting this option allows us to make some progress, see what comes out of those task forces, and better understand what the resource implications are before committing to doing a Level 3 PRA.

Disadvantages are that the insights that were out there will be delayed, and that it may result in a duplication of the scoping study effort. What I mean by that is, we spent a good amount of time and effort over the past year during this scoping study to develop different options for proceeding, and we believe we're in a good position right now to move forward with developing a project plan and obtaining support for that. If we delay things further, and we wait for future Commission direction to proceed with the Level 3 PRA, we're going to realistically have to come back and do another scoping study in preparation for that.

MEMBER STETKAR: Might it also result in some inefficient use of resources? In other words, in a sense of what Dennis was saying, that you could spend time today to develop a procedure or a process for addressing some of those research activities. When you actually do the study, you might find that, number one, you did too much in one direction, didn't do enough in another direction. And from a resource allocation perspective, it's perhaps not the best directed use of those resources. Not just duplicating previously developed work in terms of project planning, or whatever. It's the most efficient allocation of the resources you have available to address potentially risk-significant issues within the context of the PRA.

I haven't seen that listed there, but it's something that --

MR. HUDSON: A valid point.

MEMBER STETKAR: Might be -- I mean, we've seen a lot of initiatives in the past that have been interesting from a research perspective. It's not clear how directly applicable they've been.

MR. HUDSON: Okay. Moving on to Option 3, this is the full scope comprehensive site Level 3 PRA at an operating nuclear power plant. Some of the objectives for this would be to, first, be consistent with our overall mission is to extract the new and improved risk insights to enhance regulatory decision making, and to better focus our resources. And this would be accomplished, again, by incorporating those technical advances that we talked about by expanding the scope, and then by achieving the analytical consistency for the various assessments that would be done as part of the study.

We'd also like to enhance our PRA capability, expertise, and documentation. We've talked a little bit throughout our discussion here about how we would go about doing that. When talking about our PRA capability, what we mean is to build upon some of our existing PRA tools as part of this effort, and to improve upon them, and develop PRA expertise by having Staff participate as part of this effort. And we already talked about improving PRA documentation using some of the state-of-the-art technology that exists today.

We'd also like to demonstrate the technical feasibility and evaluate the realistic cost of developing new Level 3 PRAs. Again, this concept of starting off with a demonstration project where we're looking at a single site, and then once that's done we can evaluate where we are and where we need to be, and assess the need for follow-on activities.

This diagram you'll see, it's very similar to the one that we showed earlier when talking about a complete nuclear site accident risk analysis. Here you could see what the proposed scope for Option 3 really encompasses. We're taking a look at accidents involving reactor cores, spent fuel, the multi-unit component, external and internal initiators, at power and low power shutdown states. The only things that we've talked about excluding at this point are some of the additional radiological sources, such as fresh fuel in the onsite radiological waste, and initiating event hazards that are caused by deliberate and malevolent acts, such as terrorism and sabotage.

MEMBER ARMIJO: How far would you go on

the severity of the external initiating event? For example, magnitude 9 earthquake, 46-foot high tsunami, I mean, you constrained --

MR. HUDSON: I think the answer to that question would be very site-specific.

MR. STUTZKE: Well, normally, for example, when you seismic PRA, we're not interested in the magnitude of the quake, we're interested in the ground motion at the site.

MEMBER ARMIJO: Right. Whatever would drive the ground --

MR. STUTZKE: Exceeding that and some of the latest seismic hazard curves are showing when you get up above 1g, you still -- the frequency of occurrence is surprisingly high, mid minus six in some cases depending on the site you're looking at.

MEMBER ARMIJO: So, you would use --

MR. STUTZKE: I would go all the way out.

MEMBER ARMIJO: All --

MEMBER STETKAR: Yes, that's what I think --

(Simultaneous speech.)

MR. STUTZKE: No a priori truncation.

MEMBER ARMIJO: That's what I was trying to get at.

MEMBER STETKAR: Frequency or magnitude.

MR. STUTZKE: No, no a priori.

MEMBER RAY: Harold, the ones I've seen go to 10 to the minus 8^{th}. Is that --

MR. STUTZKE: That's about right.

MEMBER RAY: They get very high, 10 to the minus 8^{th}.

(Simultaneous speech.)

MEMBER POWERS: High, 10 to the minus 6^{th}.

MR. STUTZKE: I have a question for you guys. When we originally --

MEMBER CORRADINI: That's not allowed.

(Laughter.)

MR. STUTZKE: Oh, I'm sorry. Maybe you can give us some advice. When we originally wrote down radiological waste, we were thinking tritium leaks, because there were a lot of tritium leaks at the time when we were starting our scoping study. And that's what I had in mind. And it got excluded here because the risk assessment of that would really be different. It's not an atmospheric dispersion sort of thing that we know and love. It would really be off in a different field.

MEMBER STETKAR: I think that -- you know, I asked a question earlier about the metric that you're using for that non-direct health risk. Is it societal risk, or is it what else? And I think you're treading in that area when you talk about tritium releases.

MR. STUTZKE: Right.

MEMBER STETKAR: Because it's --

MEMBER RYAN: I would add that I would say that you really have to then take the leak and how do you get it to somebody's drinking water? I mean, because that's the only way you're going to get a dose of tritium.

MR. STUTZKE: That's right. It's not the sort of thing when you think of PRA, we're good at sequence modeling, but here the accident is just a leak someplace.

MEMBER RYAN: If you really want to think about tritium, I think about it as a stigma issue, because that's really what it ends up being. It's stigma, and offsite tritium in spite of it being below drinking water standard means that somebody's failed because it's not contained.

MR. STUTZKE: Yes.

MEMBER RYAN: So, that's the perception that you often get when you hear about it. So, I would tend to tread very carefully on it, if you want to do it. But what I thought -- when I saw waste, I'm thinking about large inventories of Class B or C waste.

MR. STUTZKE: That's all part of it too.

MEMBER RYAN: Class A waste, again, I would say that the radiological content is pretty small, and that tends to be not in large inventory anyway. But very often, B and C waste are campaigned significantly over many years in some cases, so that's what I was thinking. Seismic events tip over containers and break them open, and resin, and whatever all else.

MR. STUTZKE: Right.

MEMBER RYAN: And, again, even at that, that's probably in the area of kind of a mess to clean up, but as opposed to the core just having something wrong with it, I'd say it's probably way down on the list of things to worry about. So, I've been sitting here thinking about waste and what really rises to the level of this detailed analysis.

MEMBER STETKAR: I tend to agree a lot with Mike, and I come back to, if you start trying to address those issues within the context of let's call it tritium release or radioactive waste, spill of resin or something like that, then of necessity you also need to address, for example, what are the releases if you're actively cooling down a steam generator during a steam generator tube rupture event that never goes to core damage but, indeed, you've had a release -

MR. STUTZKE: I understand.

MEMBER STETKAR: -- perhaps from the ruptured steam generator over 15, 20 minutes.

MR. STUTZKE: Right.

MEMBER STETKAR: What happens to a seismic event that breaks a liquid rad waste line and results in a spill that then goes airborne? I mean, the scope -- to then try to demonstrate completeness within the regime of those minimal public health hazard scenarios tremendously expands the potential scope of the types of not only events that you need to consider from an initiating event perspective, but consequential events within the plant.

MR. STUTZKE: Yes.

MEMBER RYAN: I think that that's one cut that you can make, is the consequential versus the inconsequential. But I would not discourage you from thinking about all these various sources that are in your mind in terms of waste or other kinds of things that might be around, and tritium leaks and say well, okay, what are the magnitudes of possible sources?

And if we're going to discount them, what's the basis for doing that? And that could be within the structure of it, but you've created a floor below which you're not going to go, and above which you see more significant issues. Is that fair?

MR. STUTZKE: Yes. What I had in mind was, I think in WASH-1400 in one of the early chapters, they actually tried to do this.

MEMBER RYAN: That's right.

MR. STUTZKE: There was a cartoon that showed where all the possible radiation was.

MEMBER RYAN: Yes.

MR. STUTZKE: And then they systematically screened it out. And I think it would be valuable to reproduce that with --

MEMBER RYAN: Yes, revisit it --

MR. STUTZKE: And say well, at least we thought about it.

MEMBER RYAN: And I guess current practices, and I'm not sure how many class accumulate lots of rad waste in 55-gallon drums, or resin, or whatever else they are generating. So, I don't think it's on the site very long. My mind is the inventories stay relatively low, maybe with a few exceptions. I would encourage you to go through that exercise before you decide it's in, it's in.

MR. STUTZKE: Right.

MEMBER ARMIJO: Marty, what were you thinking about with the fresh fuel? Were you thinking of some sort of --

MR. STUTZKE: Criticality.

MEMBER ARMIJO: Just a criticality event.

MR. STUTZKE: Yes.

MEMBER ARMIJO: In the event of a --

MR. STUTZKE: Flood.

MEMBER ARMIJO: Flood. Well, it usually goes into the spent fuel pool sumps.

MR. STUTZKE: Yes.

MEMBER ARMIJO: So, I just wonder how you would get it. Anyway, my suggestion if you've got plenty on your plate without the box of yellow stuff.

MR. STUTZKE: Yes, we're comfortable with the yellow box like that, but we will try to write explanation, assuming we would start this to say well, here's why we screened this out, or why we're not treating it. Again, it's part of the 21st documentation idea, so at least we have a rationale behind it.

MEMBER RYAN: Yes.

CHAIRMAN ABDEL-KHALIK: And things outside the yellow box, things that would be included, when you talk about dry cask storage, I assume you're talking about cask loading campaigns that would be included in that.

MR. STUTZKE: That's the first part, yes, the spent fuel handling. Transport from the reactor core to the pool, and then out of the pool into the dry cask.

MEMBER RYAN: And sometimes moving the dry cask somewhere else.

MR. STUTZKE: No, we won't worry about moving that thing off of the site at this time.

MEMBER RYAN: Okay.

MR. STUTZKE: But it goes back to the spent fuel, or to the spent fuel PRA technology issue, because everything we do now, the plant is basically sitting there and something fails. Okay? We model that with the stochastic process like this. When you're moving fuel, you're deliberating doing things to the plant that then go awry. The analogy I have is, long before I came to the NRC I was involved in the chemical weapon demilitarization program up at Aberdeen, Maryland. And the idea is to destroy weapons, so you have basically a factory and the throughput rate is so many munitions an hour. And then bad things happen to them, gates close on them and they detonate, and stuff. So, we have a model for how to do that, I think. But it's really a different sort of PRA fundamentally.

MEMBER BLEY: Well, but it's a lot closer to a shutdown PRA. It's a process PRA with initiating events along the way that look like a regular PRA.

MR. STUTZKE: Precisely, yes.

MR. HUDSON: Okay. Next we'll talk about some of the PRA technology that we've considered using as part of Option 3. And to be consistent with our objective to enhance our PRA capability, we took a look at some of our agency's tools that we could be using. The SPAR models we've talked about a couple of points in our discussion today already, we'll be looking to use a SPAR model as our baseline Level 1, Level 2 PRA depending on which one we're talking about.

SAPHIRE would be used for the logic model development, sequence quantification, uncertainty analysis. And then MELCOR and MAX would be used for the severe accident progression and consequence analysis.

MR. STUTZKE: I just realized there's two things missing off of this HRA. The SRM --

MR. HUDSON: Yes I was looking for that.

MR. STUTZKE: Things like ATHENA.

MR. HUDSON: Yes. Site selection considerations have been talked about a little bit today, as well. First of all, if we want to be able to understand the contribution of multi-unit aspects to risk, we need to select a multi-unit site.

The next few bullets are really related to the quality, quantity, degree of sophistication of available information that we could be using at the start of the project. When I talk about the SPAR model capability, the Agency has 77 SPAR models. Some of those have been improved upon, and have integrative capability, 21 of them, to be precise. Fifteen of those have been expanded to include other hazards. Seven of them have been expanded to include low-power shutdown states, and three of those were enhanced as part of a feasibility study to incorporate Level 2 analyses.

The availability of MELCOR input decks. This gets back to the SOARCA project. The Surry and Peach Bottom sites have full scope MELCOR input decks already developed, so as you can imagine there could be some real cost savings if one of those sites were selected to participate.

Sites that are participating in the transition to NFPA-805 implementation would have at least worked towards developing a detailed fire PRA that would include the cable tracing, the detailed circuit analysis, so again we could achieve some cost savings if one of those sites were to participate.

And then the last three bullets are really related to what sorts of information we're trying to get out of the study. Are we trying to pick a plant that is going to be -- or a site that would be as representative as possible, the population of sites, or are we going to look at a plant that has some very specific features, because we have specific questions that we want to answer.

MEMBER STETKAR: Dan, you literally don't have easily available that graphic that shows --

MEMBER BLEY: I've got a copy of the --

(Simultaneous speech.)

MEMBER STETKAR: I think those of us on the Subcommittee all have it in front of us right now. It's not clear whether the other members have it.

MR. HUDSON: Yes, I apologize --

MEMBER STETKAR: It's a really useful pictorial to illustrate this problem.

MR. HUDSON: Yes, that one really -- yes, it talks about the NFPA-805 transition and really talks about the capability of the SPAR models for the different sites. So, yes, unfortunately, I didn't include it this time --

MEMBER STETKAR: But you can't access it?

MR. HUDSON: Yes, I don't --

MEMBER STETKAR: Okay.

MR. HUDSON: Unfortunately, I don't have access to my information here. I apologize for that.

MEMBER STETKAR: That's okay.

MR. HUDSON: Some people find that diagram very distracting.

MEMBER STETKAR: It's busy, but it's serving a --

(Simultaneous speech.)

MEMBER CORRADINI: Disturbing or distracting?

MR. STUTZKE: Distracting.

MEMBER CORRADINI: Oh, okay.

MEMBER STETKAR: But there's a lot of information on there.

MR. HUDSON: Yes, it is -- it's very useful.

MR. STUTZKE: And the conclusion at the center of the diagram where everything overlaps is an empty set.

MEMBER STETKAR: That's right.

MR. STUTZKE: That's very revealing.

MEMBER STETKAR: That's right, but there are a few places where there's --

(Simultaneous speech.)

MR. HUDSON: Exactly. And the point that Mike was just making, is that if none of the sites have a SPAR model that has been integrated to include other hazards, low power shutdown states, and Level 2 analyses. There's just not a site that exists there.

MEMBER POWERS: Every once in a while I impugn the industrial capability of doing PRA, and I am usually castigated by somebody at this table by the assurance that South Texas, or San Onofre, or someplace else has an exceptional PRA of an exceptional scope in breadth and depth. And that I should not impugn the -- anyone's PRA, because those exist. And I have to admit, I've never checked. I take people at their word, because I'm sure they know more about it than I do.

I thinking about this undertaking, have you looked at those particularly good integrated PRAs that presumably are quite up to date, especially with the changes that the plants have made in response to various regulations to validate that, indeed, if you undertook this huge effort to regain the kinds of things that you anticipate you would gain?

MR. HUDSON: The quick answer to your question is that we have not done that. We could certainly talk about that, and talk about the possibility of looking into that moving forward. But to date, we have not.

MEMBER POWERS: Yes, I just wondered. I don't know how comprehensive they are, but I'm assured by people who know lots about these things that there are some of the industrial PRAs that are quite ambitious in their scope and depth. And it would be interesting -- I'm sure they don't do everything that you might do if you adopted Option 3, but I'm sure that they do some subset of that. And it would be interesting to know that indeed we get additional stuff that we don't get right now from the combination of Reg 1150 and the IPEs and IPEEEs, and things like that.

MR. HUDSON: That's a good point to consider. We're not aware of anybody that's done a PRA that takes a look at all the things that we're talking about in terms of multi-unit risk and spent fuel contributions. But it's a good point that we can look into.

MEMBER POWERS: I mean, just particularly those two that I cite, have been relatively free to assure me, at least, that they have very good PRA. And I assume that they would be willing to share it, share with you on a confidential basis to try to understand how good are they, and could you, in fact, realize all that you aspire to get here. It's not going to answer it definitively, but it might give you some insights.

MR. HUDSON: Thank you for that.

MEMBER POWERS: One of the topics that I frequently raise, and certainly figures very prominently in my mind is CDFs and source terms, and LRFs, and things like that leave me somewhat cold. What gets me really excited are things like risk achievement worse, risk reduction worse. I would be ecstatic and awestruck were it not for the fact that those existing metrics are so crude, and I'm wondering if we would in the course of doing this, be able to explore better metrics more pointed at the kinds of things that a regulator would like to do.

MR. HUDSON: That wasn't something I talked specifically about on a slide talking about potential future uses for Level 3 PRAs, but that issue of being able to potentially explore some new risk metrics was something that we had talked about when thinking about potential future uses. It hasn't been really thrown out. When we discuss Option 3, what we're after with Option 3 is really trying to obtain some new risk insights. It wasn't meant to be a developmental exploration effort; instead, more of a demonstration. And then to sort of plant the seed for future reference. But when talking about future Level 3 PRAs, we have definitely had the discussion --

MEMBER BLEY: There have been some interesting papers over the last 15 years looking at new kinds of importance measures, and the like that give you information of a different character than we get out of the current one.

MR. STUTZKE: Importance measures are one of my personal research interests.

MEMBER POWERS: Well, I think it's a field that deserves to be mined further. And I find it much more pragmatic than the stale discussion of CDF and LERF and things like that. Numbers that I never believe them anyway, so -- but the metrics strike me as something -- because they seem to directly address the Agency mission that they are really the yield that you get out of PRA, especially when you're talking about doing a PRA for an example plant, not necessarily the plant you're particularly interested in, but you want to be risk-informed when you look at -- those metrics are the things that really inform you.

MR. HUDSON: Okay. On this slide, those of you that are on the Subcommittee have seen this before, it hasn't changed from the last time. But this is really trying to demonstrate our current thinking on how we would tackle this problem if the Commission were to tell us to go forth and do a Level 3 PRA, how would we get it done? And one of the assumptions that we've made up front is that we'd want to complete the study within a three-year time frame. So, we would --

MEMBER POWERS: Why did you pick that particular -- 36 months. I mean, there must be some reason you picked that number.

MR. HUDSON: Yes. The reason is that there has been some direction from managers to complete the study in that time frame, and the rationale for it is that when you start extending beyond three years, it's difficult to keep people engaged and interested. So, that's really a basis for selecting a 36-month time frame.

MEMBER ARMIJO: And you think you can get it done if you had the resources to go along with this, you know, if you look at your budgets and things like that, you could put together the right number of people and funds?

MR. HUDSON: Well, I think the answer to that question is if the resources were available and we would design a project plan that would enable us to complete it in 36 months --

MEMBER BLEY: Now, you've just said something that I would -- I think that bothers me, with all this. I know that the SECY follows the standard option layout kind of thing, but Option 2 is this funny little thing that I still have trouble, I haven't well defined it. Option 3 is everything in three years. If the guys had -- and this is a start, if you had laid out a CPM, a flow chart of the whole project including the knowledge gaps that need to get filled, the R&D, where that would come up, and map that piece out, not excruciating detail, but more than is on this little picture, and then take colors, segment it and say this piece of it I could get out the following useful results, and I can do that in a year and a half, and for so much money. And this other piece I can do in another hunk. You get to see if this is even -- makes sense at any level, and kind of like a proposal. And then instead of options you'd have phases of this thing that could be done. And it would say this is what we're after, and I don't know for sure how long it will take, but this piece of it will take so much time, and this piece is a little harder. You almost have to do it in general for a PWR, and in general for a BWR, you almost have to do that.

And then if, depending on which ones you pick out of the figure you can't show us here, some of this stuff is already done, and some of it's not. But you could have something that, at least to me would make a whole lot more sense. And if I were having to make a decision on it, I could say yes, let's do this phase and this phase right now, and this other stuff we'll gather more information and see --

MEMBER CORRADINI: Yes, I was going to say, the way Dennis has suggested, it would inform the Commission as to what -- if there really is some sort of resource limitation, what they want to want to pick and choose. There would be a concrete unit of a larger endeavor.

MEMBER BLEY: And you would see where the harder pieces were, where the real research lay, and all this. Right now you can't pick that out. It's real hard to see it.

MEMBER SIEBER: Well, another way to look at it is that proper management of Option 2 could assure that you never get to Option 3.

MEMBER ARMIJO: That's right.

MEMBER SIEBER: But you keep inventing new problems that you've --

MEMBER ARMIJO: Right, right.

(Simultaneous speech.)

MEMBER CORRADINI: I thought that's what he said.

MEMBER SIEBER: On kind of Option 3 with Option 2 as the front end of it.

MR. HUDSON: Well, on Option 2, just to talk a little bit about the diagram we do have here, it's -- Phase 2 here is really Option 2. And we're showing that Phase 2 is getting done at the front end of the project.

MR. STUTZKE: But that being said, if you go to the huddle room opposite my office, Dennis, you will find said critical path on the chart on the wall.

MEMBER BLEY: I think there could have been a more convincing case made from that.

MEMBER ARMIJO: You may need it to show

what the outputs are as --

(Simultaneous speech.)

MR. STUTZKE: It's not yet a resource loaded diagram.

MEMBER BLEY: And you have to flag where the real hard spots are for research, and that sort of thing, where the biggest --

MR. STUTZKE: Even in color.

MEMBER SIEBER: Well, just don't forget the long-term goal.

MEMBER BLEY: When I look at the current paper, I don't like Option 2, and I don't like Option 3. I think there's a sequence of things that would make more sense.

MR. STUTZKE: And I would hope you don't like Option 1 either.

MEMBER BLEY: You lose all of the advantages we have here.

MEMBER POWERS: Let me just explore one --

MEMBER SIEBER: How does this impact SOARCA, if at all?

MR. HUDSON: How does it impact it? I think the easy answer to that is that it's not going to impact SOARCA, because the SOARCA project is going to continue as planned to its completion.

MEMBER SIEBER: Okay.

MR. HUDSON: Now, follow-on activities might be a different discussion. The SOARCA project team is going to be wrapping up that study, and they will provide the Commission with any follow-on recommendations when they get to that point.

MEMBER STETKAR: They're planning -- this isn't SOARCA discussion, but they are planning to submit a separate SECY Paper to the Commission in a comparable time frame? Are they coming in in July time frame also, or has that been pushed back?

MR. HUDSON: No, that's been extended.

MEMBER STETKAR: Okay.

MEMBER POWERS: I didn't think it's true that you want the personnel by and large, certainly your key personnel that start a study like this to be present by the end of the study. I think that's a very good decision, and I think I do agree with you that three years is about the maximum you can expect that to happen. I think experience shows us that that's about the length of time where certainly you'll have key personnel in charge of not just the four phases you list out there, but some of the sub-phases, and you want that entire team to go all the way through it. And three years is probably the bound on which you can keep 90 percent of that team together. So, I think that's a good judgment on your part.

MR. HUDSON: Okay. Thank you for that. A couple of points to make. Here the sequencing is laid out to show you that we do an internal events Level 3 PRA first, and then we'd add on the external events later. And another point to make, that we made in the paper when talking about the three-year time line, we did talk about the fact that we could spread out the resources by taking a look at other time frames, not just constraining ourselves to the three-year time frame.

CHAIRMAN ABDEL-KHALIK: So, if these phases were to be done sequentially, at least in the first part, it would be a six-year study rather than a three-year study?

MR. HUDSON: If it were to be done linearly rather than doing any work --

CHAIRMAN ABDEL-KHALIK: Any parallel work. Right. Approximately.

MR. HUDSON: Yes, I think approximately, that would be a fair assumption.

MR. HUDSON: Advantages and disadvantages for Option 3. The first advantage is that it would provide more near-term new and improved risk insights that we talked about at the beginning as part of our overall vision for this initiative rather than waiting until later to do a Level 3 PRA. It would provide us with near-term enhanced PRA capability, and talking about having a Level 3 integrated model that would allow us to potentially address some issues that come up using a more integrated perspective.

Like Option 2, it would prevent duplication of effort. Well, Option 2 is talked about as a disadvantage, but Option 3 if we were given direction now, we would be able to capitalize on all of this work that we've been doing over the past year as part of the scoping study to develop a project plan and move forward.

MEMBER BLEY: I noticed you dropped off some things, but you've dropped off the Staff's training, and from that discussion earlier, I think that's a really key issue.

MEMBER CORRADINI: You don't know who your team member -- I mean, I really think this is important. You don't know who your team members could be in the future if you don't develop them as part of the -- with the experts in doing this effort. There's nothing better to train than to doing something.

MR. HUDSON: You're right. When talking

about the enhanced PRA capability as part of that second bullet, that really is meant to encompass the expertise that would be developed as part of this effort, as well.

The real disadvantage that we see here, and the one that we'll talk about here shortly is that it's, obviously, a resource intensive study, would require more resources than we've already requested for this. And the reallocation of resources to support this effort would take away from some of the mission-critical work that we're doing.

MEMBER CORRADINI: So, can I ask that maybe this is -- the Chairman will tell me this is not appropriate maybe because we're talking resources, but -- so what are the mission-critical things that rise above this?

MR. HUDSON: Well, it's difficult to answer that question, because the assessment of what actually would rise above this --

MEMBER CORRADINI: I might be ruled out of order.

MEMBER STETKAR: No, no, here I think it is because, as we see on the next slide, the whole crux of the recommendation is based on resources. So, this is an area where I think, of necessity, we need to understand those arguments.

MR. HUDSON: We'll go ahead and move on to the next slide, and get down to the punch line here. We, the Staff, believe that a new and more comprehensive site Level 3 PRA would be beneficial for all the reasons that we've talked about here today. The reality is that obtaining the resources necessary to support this, obtaining additional resources is unlikely. So, to work within the resources that we have available to us, reallocating resources to support the Level 3 PRA would be really difficult, because, first of all, we have a limited pool of risk analysts that are already doing good, important mission-critical work. And, as I talked about before with some of these other related efforts and the task forces that are out there, and the uncertainties surrounding the recommendations that are going to come from them, we don't really fully appreciate yet what the potential for work could be. So, based on this assessment we, as you know --

MEMBER STETKAR: In that sense, back up a little bit. In that sense, though, are you making a recommendation based on concerns about Commission decisions about conflicting priorities for which you don't have any actual evidence in hand? In other words, if I take away all of those concerns, the worries about well, this might happen, or that might happen, or the roof might cave in today, or the cat might die, what then would be your recommendation?

MR. HUDSON: I don't think that we would focus on the unknowns there, as what's driving our decision. The first bullet here when focusing on what we do know now --

MEMBER STETKAR: Okay.

MR. HUDSON: We know that we have this work assigned to a limited pool of risk analysts, and we're resource-constrained. Taking a look at that, that's really the driver. But then when we think about the bigger picture and these other efforts, it's another piece of information --

MEMBER STETKAR: I just want to make sure that, indeed, the decision was based primarily on the first bullet, because I read a little bit of some of the other concerns about what might be transpiring over the next N months, and that's always the case. You can't plan for every eventuality. And you shouldn't, necessarily, be basing decisions about specific options going forward on speculation. So, I'm glad to hear that.

MEMBER POWERS: In thinking about this,

it's probably important to your preparing options for your -- the Commission decision, but in thinking about this there are a lot of countries that make a lot of use of the risk information documents that we prepare. And have you thought about internationalizing this undertaking, inviting partnerships with other countries to if not contribute, to participate in the study, and setting up a structure with a scientific steering group that would address some of the phases and things like that?

MR. HUDSON: That's something that we have certainly thought about, we talked about it throughout the scoping study. But I think in this situation it would leave you as being analogous to the engagement with industry, and trying to figure out --

MEMBER POWERS: May be premature to do that.

MR. HUDSON: Exactly. That this was, again, truly an options paper where we considered options that didn't involve doing a Level 3 PRA, so I think as we move forward and we get a sense for the Commission's priorities and what their direction is going to be, if we obtain support from them, I think at that point we'd certainly be talking about the possibility of engaging with international counterparts.

MEMBER POWERS: One of the things that I think I have learned from watching international programs is, resources aside, one of the advantages you get is you get a lot of different eyeballs looking at the issue. And though you get a lot of nonsense out of that, the one or two pearls of wisdom that come out of that process sometimes is worth putting up with a lot of nonsense.

MEMBER CORRADINI: That's like the ACRS.

CHAIRMAN ABDEL-KHALIK: Now, looking at --

(Simultaneous speech.)

MEMBER CORRADINI: On a good day.

MEMBER POWERS: Only, the lot of nonsense may be over in that corner, but the rest of us don't give in to that.

CHAIRMAN ABDEL-KHALIK: The third point on this slide, the reallocation of resources is probably an artifact of the time line that you have selected in a sense that if you're preferring Option 2 to Option 3 because of the concerns regarding resources, that doesn't have anything to do with the merits of Option 3, or the composition or structure of Option 3. It directly derives from the time line --

MR. HUDSON: That's right.

CHAIRMAN ABDEL-KHALIK: -- that you have selected for implementation of Option 3. And, therefore, if -- at least for the first 18 months, Option 3 and Option 2 would be identical if these components are done sequentially, rather than concurrently.

The question then is, if that were the case, if one were to do these phases sequentially, would that detract from the outcome of Option 3, if you were to extend it over a longer period of time? Do you understand the question?

MR. HUDSON: I do, just taking a moment to digest and think about it.

MEMBER CORRADINI: He's developing his answer.

MR. HUDSON: I'm just thinking about it from a process perspective, and making decisions about supporting the effort, and making decisions to reallocate resources.

CHAIRMAN ABDEL-KHALIK: I mean, allocation of resources is done on a rate basis, rather than a lump sum basis. And, therefore, if this thing is to be done sequentially in terms of phases, the impact on resource requirements would be minimal. It's just that it's going to be done over a longer period of time.

MR. HUDSON: That's right. And, again, getting back to the decision that we made to develop a three-year project plan for Option 3, we were purposefully trying to get away from the long protracted study for a variety of reasons. We talked about some of the issues associated with personnel coming in and out of the project that impacted the SOARCA study.

MEMBER ARMIJO: It seems to me you've already prioritized this work as being somewhat more than current mission-critical work, and potential for work for follow-up from Japan. And I think you could, assuming that -- I kind of like Dana's idea to focus on something that's really a relevant, major event where we have not much, I guess, knowledge. We have the 23 BWR4s with Mark I containments in the U.S. It might be the driver that you need to get the Level 3 PRA tools, everything put together if you focused it that way, and it would still meet your mission, and your resources, then you could determine and the Commission could guide you on whether they thought the resources really could be made available. You're always having to prioritize, but if it's important enough, I think you could.

MR. COE: If I may, one of the advantages that we see in Option 2 is that our paper will be going to the Commission at about the same time as the Near-Term Task Force looking at the Japanese events. So, we don't know what the task force is going to recommend, but we think -- but not knowing that, still we think that there might be a smart way to -- for the Commission -- yes, exactly, to ask the Staff to work out a program that could take advantage of some of our thoughts here, maybe address some near-term questions that the Commission may have, and yet that would provide some stepping stones toward our ultimate goal in this project.

MR. HUDSON: I don't think Slide 28 is coming as any surprise based on the discussion that we've had. I think everyone is aware that the Staff at this point is recommending --

MEMBER STETKAR: How close -- I was going to say it wasn't until 4:30 in the after --

MR. HUDSON: Three --

MEMBER STETKAR: This is a surprise.

MEMBER ARMIJO: It was three before. Right?

MEMBER STETKAR: There was three before.

(Simultaneous speech.)

MR. HUDSON: That's right, when we were

here in May, the recommendation was Option 3. But, again, in this dynamic environment that we're in with the resources --

MEMBER STETKAR: And just to be clear, this is strictly the change from the Subcommittee meeting until yesterday afternoon and today. This is strictly based on resource considerations.

MR. HUDSON: The Staff's recommendation is not based on resources.

MEMBER STETKAR: It's not a fundamental rethinking in terms of technical advantages.

MR. HUDSON: That's right.

MEMBER STETKAR: Or anything, strictly resources.

MEMBER BLEY: You've changed wording a bit in the SECY. And now when I read Option 2, Option 2 really has words like doing this in preparation for continuing with the Level 3 study, and similar merits said something which might get funded partway through this or something. But it almost sounds like it's Option 3, and it's a little --

MEMBER STETKAR: That's why my flip comment about the marketing of the first bullet about bringing things to closure before finality. I think some of those words, my interpretation, are --

MR. HUDSON:

MEMBER RAY: You're right, some of the language has changed. And the reason for that is that, again, the Staff was moving towards Option 3. We believe that it would be very beneficial to do a newer, more comprehensive Level 3 PRA right now. Understanding the resource constraints that we're working with, Option 2 became more attractive because it allowed us to use resources that we have already requested to support future Level 3 PRA activities to make what we believe would be good, important progress towards doing a Level 3 PRA.

I think selecting Option 2 is making a decision that doing this Level 3 PRA study would be worthwhile, it's just that the timing is not quite right. So, let's do some work between now and continue to evaluate the budget climate. And once the time is right, we can come back to the Commission and say hey, we've continued to make some good progress in this direction. The resource situation is more supportive now, and we're going to provide you with options for proceeding with this Level 3 PRA.

MEMBER BLEY: If Option 2 went a little further and said we've picked a site where we're eventually going to do the Level 3 PRA, and we've used existing PRA like you guys were talking to put the work we're doing on Option 2 in context, it would ring a little better. This still looks like you could put a fair amount of work into things that once you pick the site later when you do Level 3, that you might have to not get half of what you'd already done being directly applicable to where you were headed once you pick that. So, if it were a little more as the precursor, you clearly picking that site and --

MEMBER STETKAR: Dennis, I think we have to be careful because we have to write a letter to the Commission today. And we're not going to have an option to see another yet revision of the SECY Paper. I think we have to write our letter based on what we have there.

MEMBER BLEY: We, indeed, have to write our letter.

(Simultaneous speech.)

MEMBER STETKAR: But planting the seeds of change in the SECY Paper isn't going to help us.

CHAIRMAN ABDEL-KHALIK: Sanjoy?

MEMBER BANERJEE: Yes. Can I just ask, what do you really mean by research? Is it something to do with methodology, or is it application of existing methodology to some new problem, like a spent fuel pool or something?

MR. HUDSON: I think it depends on the issue that we're talking about.

MEMBER BANERJEE: I see your scope of research areas, and it's not clear to me what is research and what is application.

MEMBER POWERS: Well, I think it's safe to say that nearly everything is application.

MEMBER BANERJEE: Right. So, there is no new methodology you're developing.

MEMBER POWERS: Oh, no, I think there are new methodologies.

MEMBER BANERJEE: Okay. I'm asking them to distinguish between the two.

MR. STUTZKE: Certainly, in the human reliability analysis, that's research.

MEMBER BANERJEE: Okay.

MR. STUTZKE: You get into the SAMGs and making Mgs.

MEMBER POWERS: And there are other things like, for instance, the PHEBUS program is wrapping up, and we'll be introducing a whole new way of treating iodine chemistry, for instance, as example. It's a new methodology but it's really applied, and it's --

MEMBER BANERJEE: I'm just wondering, it's just a thought, whether it might be interesting if it is that, to actually apply it to a real life Level 3 PRA, because that's an application. Unless you're doing something really innovative and new, I don't see why you need to close these gaps without just going for the jugular and doing the real thing.

MEMBER POWERS: Well, I think the problem that they have -- I'm speaking out of turn, I know, but I think the problem that I see is that when they conduct the study as done by Option 3, that would be the last thing that would be done for another decade, decade and a half. And if you're on the cusp of making a lot of changes in your computational methodologies, you might not get them done first, because you're not going to get to redo that study and correct things for another generation of analysts coming in.

MEMBER BANERJEE: Sure, Dana. The only thing is doing it in sort of -- as we all know, it's hard to do things in a sort of a semi-vacuum, if you have something going on, the application often drives the development. Just a thought. I mean, this is -- if it was a thermal hydraulics problem, I would tackle the real problem and do it, rather than --

MEMBER CORRADINI: Lo and behold, you'll

get a methodology out of the --

MEMBER BANERJEE: We may get a methodology out of it.

MEMBER STETKAR: We're going to run short on time here, so --

MEMBER BANERJEE: That's just a comment.

MEMBER STETKAR: Any other comments or questions from the Members? Obviously, we're going to have some discussion over this topic later today.

Dan and Marty, thanks a lot for the presentation. I think you did a good job on getting us from the Subcommittee meeting to where we are today, and thanks a lot for the help and the discussion. Appreciate it. And, Mr. Chairman, it's back to you.

CHAIRMAN ABDEL-KHALIK: Thank you. At this time, we're scheduled to take a 15-minute break. We will reconvene at 3:00 p.m. At that time, we will discuss NRC Bulletin 2011-01, Mitigating Strategies.

(Whereupon, the proceedings went off the record at 2:43:30 p.m., and went back on the record at 2:59:15 p.m.)

CHAIRMAN ABDEL-KHALIK: We're back in session. The next item on the agenda is NRC Bulletin 2011-01 entitled "Mitigating Strategies."

This bulletin was issued by NRC on May 11, 2011 requesting that licensees verify their continued compliance with 10 CFR 50.54(hh)(2). It also requests that licensees provide information regarding their mitigation strategies in order for the Staff to determine if further regulatory action is warranted in light of the Fukushima Daiichi event.

At this time, I invite Ms. Stacey Rosenberg to begin the Staff's presentation.

MS. ROSENBERG: Good afternoon. I'm Stacey Rosenberg. I'm the Chief of the Generic Communications and Power Uprate Branch in the Office of Nuclear Reactor Regulation. I want to thank the ACRS for the opportunity to discuss Bulletin 2011-01 entitled "Mitigating Strategies."

The bulletin was issued as a compliance bulletin on May 11th, 2011 with ACRS and CRGR reviews deferred. We are here today to brief the ACRS on the bulletin in order to facilitate your review.

CRGR endorsement has been requested in parallel. Eric Bowman, who has been leading our B5B Mitigating Strategies effort since 2008 is going to cover the background of the bulletin, and what we hope to accomplish by its issuance. Eric.

MR. BOWMAN: Thank you, Stacey. Good afternoon, gentlemen. I'll get right into the meat of the presentation.

The reason why we issued the bulletin 2011-01 was to achieve a comprehensive verification of compliance with the requirement for the Mitigating Strategies that were imposed following the terrorist events of September 11th, 2001.

In addition, we will be using the information that we received in response to the 60-day portion of the information request to determine if any further assessment is necessary, if our current inspection program needs to be enhanced in any ways, or if any further regulatory actions are necessary.

The Fukushima Daiichi fuel damage event showed us that additional initiating events besides the security events similar to those that were in place that happened on 9/11 and motivated us to implement the B5B requirements and the subsequent license conditions, and finally 50.54(hh)(2), highlighted what the significance of those Mitigating Strategies could be in additional initiating events, such as beyond design basis natural phenomena.

Our inspection efforts historically between the issuance of the order, the Interim Compensatory Measures Order EA02-026, it included Section B5B initiating the requirement for the

Mitigating Strategies in 2002. Following an intense development process involving industry, we conducted a comprehensive set of inspections between 2005 and 2006 on what we termed the Phase 1 requirements.

Between then and 2007, we underwent two further phases in the development process for the Mitigating Strategies, Phase 2 dealing with the spent fuel pool requirements, and Phase 3 dealing with the core cooling and containment requirements.

In 2008, we completed a comprehensive verification by inspection that all of the licensees had strategies implemented, and things were in place with any deficiencies noted added into the licensee's Correction Action Programs. Since then, inspection of the Mitigating Strategies has been integrated into the Reactor Oversight process. It's currently part of the Triennial Fire Protection Inspection Program. Every three years, we have, I believe it's 18 hours of inspection effort on a sample basis for the Mitigating Strategies per licensee.

Because it's just on a sample basis now, and given the events in Japan following the earthquake, we had the desire to once again achieve a comprehensive verification of the compliance with the requirements.

The first portion of the information requested by the bulletin is on the slide here. Essentially, we're asking to verify that the equipment is in place, and is capable of performing the functions that it's in place to perform; that is the Mitigating Strategies to maintain or restore core cooling, containment and spent fuel pool cooling capabilities.

Further, we're asking the readiness of the staff of the sites and the procedures themselves based on any potential changes that may have been made to the configuration of the sites since the strategies were first implemented.

The basis for that request is to verify the current capabilities of the sites to actually execute the Mitigating Strategies if they were called upon to do so right now.

MEMBER CORRADINI: Just to make sure I understand. Normally, you do kind of a sampling, and now it's comprehensive, every site, I'm sorry, every licensee, every site you're going to go through and look at. You are in the process of going -- or asking them to look at it.

MR. BOWMAN: That's correct. We have asked them to go through and perform a comprehensive verification. There was already an industry-sponsored initiative to do so --

MEMBER CORRADINI: Right. Initiated by INPO, if I remember correctly.

MR. BOWMAN: That's correct.

MEMBER CORRADINI: Okay.

MR. BOWMAN: So far, we've received one of the 30-day responses. I believe it was Plant Vogtle confirming compliance for both questions.

MEMBER CORRADINI: And when they respond, it can be a simple affirmation to your two -- to the 30-day request, and then if not, they can provide details. What is the expected response in this case, just simply an affirmation?

MR. BOWMAN: The expected response is an affirmation they have the capability to do the strategies currently. They would, of course, need backup documentation on site that would be subject to verification by the inspectors.

MEMBER BLEY: I'm assuming they've already — to this bulletin, they have already confirmed this as being in place over the last several years. Is that true at all plants?

MR. BOWMAN: That's correct, they should have.

MEMBER BLEY: So, this is just a reconfirmation.

MR. BOWMAN: This is just our confirmation on a comprehensive basis that everything is in place now, and that any corrective actions that were necessary for deficiencies they found have been completed, or they can provide us with the details of the deficiencies that exist along with their plans for correcting the deficiencies.

MEMBER BLEY: For the years that they've made changes to those systems, they need to report that to the Commission?

MR. BOWMAN: The details of the strategies that they've implemented are managed under their Commitment Management Program, so typically we get the reports through reports of changes to their commitments, if it rises to the level of something that requires a commitment change.

MEMBER BLEY: Okay, thanks.

MR. BOWMAN: But, otherwise, it's just we re-verify it on a sample basis currently during the triennial fire protection inspection.

CHAIRMAN ABDEL-KHALIK: Is this request different in any way than INPO's IER-1101?

MR. BOWMAN: It requires a response to us, is the major difference.

CHAIRMAN ABDEL-KHALIK: But in terms of content?

MR. BOWMAN: It should not be significantly different from what they did for INPO's IER-2011-01. I don't think there's -- this part of it.

CHAIRMAN ABDEL-KHALIK: So, this part and the outcome would be, essentially, an affirmation to you that they have done what presumably they had already done under INPO's IER-1101.

MR. BOWMAN: A possible outcome of INPO's IER-2011-01 would have been identification of deficiencies, and documentation within the Corrective Action Program. There may be changes based on the licensee's having actually accomplished the corrective actions, so there could be a delta between what they reported to INPO and what they are going to report to us.

CHAIRMAN ABDEL-KHALIK: But your's is actually a subset of what they had, essentially, prepared for INPO.

MR. BOWMAN: Right. My understanding of the INPO IER is that it also looked at station blackout, and a few other items.

MEMBER RAY: It would have gone beyond this, I think.

MR. BOWMAN: Right.

MEMBER BLEY: That's what I'm trying to get to. Thank you.

MR. BOWMAN: Okay. The second portion of the information request due on the 10th of July consisted of five questions. The first three questions we're asking deal with the licensees programs for maintenance, testing, and control of the equipment that they acquired for the mitigating strategies. And the fourth and fifth question dealt with the procedure of control, accounting for configuration changes in the plant, and management of their guidance, including the training of the personnel to insure that they can continue to implement the mitigating strategies. And, finally, the fifth question dealt with the management of offsite support, emergency responders and so forth to B5B initiating events.

The reason we asked these questions in the 60-day information request deals with the requirement of 50.54(hh)(2) for the implementation and, essentially, the maintenance of the Mitigating Strategies. They have a continuing requirement to be sure -- to assure that they have strategies in place that are intended to --

MEMBER RAY: The microphone.

MR. BOWMAN: Oh, sorry.

MEMBER RAY: That's all right.

MR. BOWMAN: Anyway, the idea behind the 60-day request is to verify the continuing nature on a going forward basis that they have programs in place that will assure continued ability to maintain and implement the strategies in the future.

Part of the reason why we felt it was appropriate to ask these questions is because the guidance that we have outstanding for compliance with 50.54(hh)(2) is fairly limited in the detail on what would be necessary for a licensee to continue to maintain compliance with 50.54(hh)(2).

That guidance is contained in the Phase 1 Guidance Document that was sent out in February of 2005. That document has been -- was designated the time Safeguards Information. The Office of Nuclear Security and Incident Response is reviewing the guidance to see if we can redesignate it, and make it more widely available.

The other piece of guidance for the Phase 2 and Phase 3 Mitigating Strategies is the document

NEI 06-12 Revision 2, Phase 2 and 3 Submittal Guideline that was endorsed in December of 2006.

Originally, the NEI 06-12 Revision 2 was designated for official use only, security-related information. It was recently redesignated and made publicly available in order to assist our counterparts in the international community with any preparations they might desire to make to similar needs as we have, in part because now that the industry has filled all the gaps in the requirements, we felt there was no longer a justification for withholding it from public distribution.

These are what the words in NEI 06-12 say about the maintenance, testing, and control of equipment. Essentially, it's just that the licensees will meet standard industry practices for procuring and maintaining commercial equipment.

The standard industry practice is a little bit undefined. We've seen a bit of a spectrum of approaches across the industry, so we're asking for the information so that we can verify that there is, indeed, a defined standard industry practice for equipment that's used for Mitigating Strategies, or if we need to give further guidance in this area.

The fourth question that dealt with

training, the guidance that we have outstanding refers back to the level of training that's in place for the severe accident management guidelines. As you're no doubt aware, the severe accident management guidelines do not have a regulatory requirement, and don't have a truly defined set of training requirements, so we're looking to see is there a standard that the industry is using that we can define by some means as to what the level of training that's appropriate and should be required for the Mitigating Strategies, or if we need to take any further regulatory action on that.

And, similarly, we don't have a well-defined means of maintaining oversight of the offsite support that's necessary for the Mitigating Strategies. We looked at it during the B5B Phase 1 efforts in the inspections, and we again looked at the maintenance of the Memoranda -- Agreement of Understanding with the offsite responders during the Phase 2 and 3 inspections in 2003, and as sampled during the triennial fire protection inspection that the guidelines are little bit light on what should be required for the Memoranda of Agreement and Understanding.

Once we get the 60-day responses, as I mentioned before, we'll be analyzing them to determine if there is, indeed, a standard industry practice for these items. And we'll evaluate to see whether or not that assuming that there is a standard practice in place, whether it's adequate or can be better informed by other requirements that are out there, for instance, requirements that are outstanding for maintenance in the fire protection area, or other emergency response areas.

CHAIRMAN ABDEL-KHALIK: And, presumably, the big picture purpose of this is to determine whether those Mitigating Strategies combined with the information that you have requested regarding maintenance, testing, and control of equipment, training, and offsite support will, indeed, be effective in addressing any event beyond design basis event for these -- for which these equipment may be called upon. And if that is the case, during an event to ascertain whether or not these equipment are, indeed, effective, one needs to know the status of the plant.

MS. ROSENBERG: It will help us determine the reliability and availability of the equipment for use.

CHAIRMAN ABDEL-KHALIK: Let me finish. And to do so, one needs data for critical plant equipment. So, where in all the information that you are requesting will the applicants provide information to you regarding instrumentation that may be needed to determine, or keep track of those critical plant parameters that would allow the applicant, or anyone else, to determine whether or not these Mitigating Strategies are effective, and whether such instrumentation would actually be available during the conditions in which this event takes place.

MR. BOWMAN: We did not request that information in this bulletin, because this bulletin was issued as a compliance verification. We are merely requesting information on the extent to which the licensees are meeting the requirements as they're laid out in the regulations, and informed by the regulatory guidance that's outstanding.

In addition to that, the Near-Term Task Force is looking at things that can be changed with the regulatory requirements or guidance that's outstanding that may assist in --

CHAIRMAN ABDEL-KHALIK: So, would you agree then that absent information on the instrumentation that is needed to monitor the plant status and the survivability of these instrumentations, one cannot ascertain whether or not these Mitigating Strategies will, indeed, be effective?

MR. BOWMAN: I would agree, yes. One of the difficulties with the 50.54(hh)(2) area, the Mitigating Strategies don't have a well-bounded design basis, if you will. There is no set of boundaries to what the initiating event that would require implementation of the Mitigating Strategies. Essentially, if you will, they are just to provide a toolbox that a licensee can go to and choose in the event of a beyond design basis event. I will try to implement this strategy, because I believe it will be effective.

CHAIRMAN ABDEL-KHALIK: But, ultimately, a strategy means a procedure. And a procedure needs data.

MR. BOWMAN: Yes.

CHAIRMAN ABDEL-KHALIK: Data needs instrumentation. So, would you agree then that a piece is missing in this process?

MR. BOWMAN: It would be nice if we had a well-defined set of criteria, and well-defined accidents that we were implementing the requirements for, but that's not the case.

CHAIRMAN ABDEL-KHALIK: But one does not, necessarily, have to approach this from a specific accident, but you can approach it from specific critical plant parameters --

MR. BOWMAN: Yes.

CHAIRMAN ABDEL-KHALIK: -- by which one can determine the overall condition of the plant, and whether the condition of the plant is stable. And based on that, determine what minimum instrumentation would be required, and whether or not those instruments have to be hardened in order for one to determine whether or not these Mitigating Strategies are, indeed, effective.

MR. BOWMAN: I understand what you're getting at, but it's outside the scope of this bulletin.

CHAIRMAN ABDEL-KHALIK: Okay.

MEMBER STETKAR: Eric, to kind of -- and I have to profess near complete ignorance on this topic, so excuse me if I'm asking a really silly question. When licensees define their Mitigating Strategies, when they establish their equipment and programs, I thought they were supposed to consider the sort of generic concept of a loss of a large area of the plant.

MR. BOWMAN: That's correct.

MEMBER STETKAR: If that's correct, and it's a nondescript, I mean, regardless of whatever guidance there might be out there, it's a nondescript fairly severe event. As a follow-up to Said's question, do those Mitigating Strategies, either procedures or equipment, include guidance about use of instrumentation that might be available, for example, outside of this nondescript large area event?

MR. BOWMAN: They do.

MEMBER STETKAR: They do, okay.

MR. BOWMAN: But they don't specify the equipment or the instrumentation will necessarily be available. They provide guidelines, if this is available, refer to it. And, in general, some of them -- if that's not available, refer to something else.

MEMBER STETKAR: Okay.

MR. BOWMAN: A lot of the difficulty is many of the Mitigating Strategies assume that you've got a loss of all internal power distribution so internally powered instrumentation, that is instrumentation that relies on the site internal power distribution, we don't assume as an entering argument is available. There are some of the strategies that allow for use of things like opening up penetration connectors in order to tape off where the instrument leads are in an effort to get an indication of what the plant parameters are, and so forth. But there is no guarantee that that information will be available.

MEMBER CORRADINI: Just one other follow-up so I understand. I think I kind of get it. So, if you go to Licensee A, and they have a group of systems, X, Y, and Z, and if they're available they are going to perform a series of functions, do they have a design base that they can show you that they decided that the pump is going to be this big, and the power supply is going to be this big? You have to pick it based on something, so what do they -- do you have that information?

MR. BOWMAN: Yes.

MEMBER CORRADINI: Okay.

MR. BOWMAN: Yes, they provide an engineering basis for their determination that, for example, a pump would be able to provide a certain amount of flow, and so forth.

MEMBER CORRADINI: Okay.

MR. BOWMAN: It wasn't a QA basis, but it was something that was required to be auditable, so that we could go back and verify that we agreed that, indeed, that pump could deliver that amount of flow.

MEMBER CORRADINI: And if I went to

Licensee B, C, and D, I might find different bases for the Complements X, Y, and Z.

MR. BOWMAN: I have no doubt that you would find different bases.

CHAIRMAN ABDEL-KHALIK: But would you find an assessment of the survivability of various instruments, or just if Instrument A is available, use it. If Instrument B is available, use it.

MR. BOWMAN: It would be the latter, in general, because we hadn't defined what the initiating event is with B5B, or the license conditions that came out of it, or 50.54(hh)(2). We just said something bad has happened, and you've lost a large area of the plant. So, we developed through a lot of brainstorming and looking at what could be done assuming that certain plant systems were no longer available, what could be done to try and provide the key safety functions by other means.

MEMBER ARMIJO: I'd like to ask you a question. If this toolbox, I like that idea of a toolbox of important equipment that you'd like to have, but if this toolbox and the training that we require, or that we put in place, if that had been available in Japan during Fukushima, would it have helped at all in the loss of offsite power for an extended period, flooding of critical equipment, loss of fuel, everything bad went wrong. Eventually, people started bringing in equipment and got things recovered somewhat.

I'm just trying to get a feeling would this have really been a big help if it had been available, at least this kind of equipment, this kind of preparation, if it had been available? And I'm not sure the Japanese don't have an equivalent program.

MR. BOWMAN: Knowing what we know about what happened in Japan, it could have helped, as you said, if the equipment had been available and they had the procedures or the strategies in place to do so.

As they were going through, and I was hearing of the ad hoc mitigation efforts they were making, a lot of them reminded me a lot of what the Extensive Damage Mitigating Guidelines, which is what the generic industry term for the B5B Mitigating Strategies wound up being a lot of ad hoc mitigation that the Japanese did reminded me a lot of what our Mitigating Strategies were.

MS. ROSENBERG: And I think it would have depended where they had located the equipment on site.

MR. BOWMAN: Right.

MEMBER ARMIJO: Whether it was flooded, or whether it was --

MR. BOWMAN: Whether it was there still.

MEMBER ARMIJO: Yes, yes.

MR. BOWMAN: As you're no doubt well aware, the Near-Term Task Forces looking at the issues, including the Mitigating Strategies that were in place after 9/11 to come to a conclusion and make recommendations on whether or not they should be -- there should be any changes to the requirements. Our intention is to look at what the Near-Term Task Force comes out with as recommendations, and where it's appropriate we will fold in any potential regulatory actions that outcome from Bulletin 2011-01 with resulting efforts to insure that everything --

MEMBER CORRADINI: But the 30-day response to you guys, and the 60-day responses being funneled up to the Task Force, I assume.

MR. BOWMAN: Yes.

MEMBER CORRADINI: Okay. So, that you guys are in communication such that the response you get in 30 days and 60 days will help inform them as to what they decide might be potential options.

MR. BOWMAN: I would expect that the Near-Term Task Force will be very close to being done before we get --

MEMBER CORRADINI: The 60-day --

MR. BOWMAN: -- the 60-day response.

MEMBER CORRADINI: Okay.

MR. BOWMAN: And well before we have a chance to analyze the implications of the 60-day responses.

MEMBER CORRADINI: So, the 30 days are about all they're going to have.

MR. BOWMAN: I will be sharing the other responses with them, as well, if we get them earlier than 60 days, there is no -- nothing prevents a licensee from providing the information earlier. Although, I don't anticipate --

MEMBER CORRADINI: That's fine. I was just curious.

MR. BOWMAN: -- too much earlier.

MEMBER CORRADINI: That's fine. Thank you.

CHAIRMAN ABDEL-KHALIK: Back to the issue of instrumentation, as we were discussing earlier, these strategies would say if Instrument A is available, use it. If it is not, use Instrument B, if it is available. Do they also go into a situation where neither A nor B is available?

MR. BOWMAN: Yes. One of the things in NEI 06-12 Revision 2, which is the industry guideline that we endorsed for the Phase 2 and 3 strategies, one of the requirements was a portable independently powered pump. Typically, the independently powered pumps can be equipped with flow meters, or discharge pressure meters and so forth, and most of the ones that I've seen have at least a discharge pressure flow meter, or a discharge pressure gauge so that you can get some inkling of what the downstream pressure is, or how much flow you're delivering.

CHAIRMAN ABDEL-KHALIK: But would that kind of information -- have you independently made a determination that that information would be sufficient to ascertain the status of the plant?

MR. BOWMAN: No, it would not.

CHAIRMAN ABDEL-KHALIK: Thank you.

MR. BOWMAN: Finally, in addition to the Near-Term Task Force, we have two sets of guidance out there for compliance with 10 CFR 50.54(hh)(2). The NRR's current guidance is, as I mentioned, the Phase 1 guidance document of February 25th, 2005, and NEI 06-12 Revision 2 as endorsed by the letter that was sent in December of 2006.

The Office of New Reactors has endorsed a revision to NEI 06-12, Revision 3 is that version which includes some information about applicability to new reactor designs. And, also, has an interim staff guidance out there on additional requirements, including the equivalent to the Phase 1 guidance document.

Any regulatory action that we take as an outcome of Bulletin 2011-01 will coordinate with the Office of New Reactors to insure that we maintain technical consistency. Eventually, the end desire will be a single set of regulatory guidelines for both.

CHAIRMAN ABDEL-KHALIK: How would you do that if all the information on which you would base the decision as to whether or not additional regulatory action is necessary will be based on information provided by operating plants?

MR. BOWMAN: All of the equipment that we're talking about for the operating plants and, indeed, a lot of the equipment that meets the requirements for the Mitigating Strategies in new reactors is portable equipment, such as the portable independently powered pump, hoses to connect it to things, essentially emergency equipment of that nature. So, the meat of what we're looking at for the 60-day requirements, the first three questions deal with the management, testing, and controls of that equipment. Because that equipment is not installed in the plant, there are easily parallels between what you would have accomplished for a plant regardless of whether it's a new Part 52 licensed plant, or if it's a currently operating reactor.

The other pieces dealing with coordination with offsite support, I don't think would be very different for a new reactor, or currently operating reactor. And the same with how the programs are maintained to look at things like configuration control, and requirement for updating the procedures for any changes of that nature, and maintenance of the procedures that are in place, and training of personnel.

MEMBER STETKAR: I'm just curious, Eric, and I haven't read NEI 06-12, so I don't know how much you can talk about it, but given what you just said, and something you had sort of flashed earlier, you said Revision 3 addresses issues for new reactors. Why are they different, or what are the differences in terms of the strategies that depend on whether or not I have a new reactor, or a currently operating plant?

MR. BOWMAN: Revision 2 provided sets of Mitigating Strategies for pressurized water reactors and boiling water reactors. The desire in Revision 3 was to leave it a little bit further open into any other type of reactor that may wind up getting licensed, how to go through and determine what sort of additional strategies would be appropriate for a different type of reactor, and so forth. There were a couple of other very subtle differences.

MEMBER STETKAR: I was thinking more in the line of is there something unique, for example, for passive plant design versus something else? And I -- thanks. I understand.

CHAIRMAN ABDEL-KHALIK: But ISG-16 does not fully endorse Rev 3, does it?

MR. BOWMAN: It provides some amplifying information on what would be needed for Rev 3. It doesn't -- I would have to go back and look at ISG-16 to see if there's any part that it takes exception to. I don't recall it. The Office of New Reactors is actually cognizant of it. I'm just familiar with it, because I assisted them with providing them the inspection results, the insights that we had into what we saw when we did the 2008 series of inspections.

With that, are there any further questions that I can assist you with?

MEMBER ARMIJO: I have a question related to the NEI document. I have not read it, so do you know if the industry has provisions for knowing what type of equipment is available among all, and available for sharing in the event you got into a situation where -- some mind-boggling event that wiped out even what you had at your site for promptly getting -- knowing what was available nearby and getting it to your site. Is that kind -- is that included in that NEI guidance?

MR. BOWMAN: It is not documented in the NEI 06-12 document. My experience with having gone out and done some of the verification inspections, at sites that are part of multi-site organizations, such as TVA or other ones of that nature, they know what type of pump their sister facilities have, and how long it would take to get it from one place to another. My understanding is that INPO maintains that kind of information, but I can't --

MEMBER STETKAR: I've heard either INPO or NEI claims -- I don't know whether it exists yet --

MEMBER BLEY: I heard the EDO talk about it, but that there is a formal program in industry. It's not NRC.

MEMBER ARMIJO: No, I understand that.

CHAIRMAN ABDEL-KHALIK: Does not exist yet.

MEMBER BLEY: That's not what I heard.

MEMBER STETKAR: I've heard it does.

CHAIRMAN ABDEL-KHALIK: Well, are there any questions for Mr. Bowman? Any other questions?

(No response.)

CHAIRMAN ABDEL-KHALIK: Well, thank you very much. We appreciate it.

MR. BOWMAN: Okay. Thank you.

CHAIRMAN ABDEL-KHALIK: At this time, we are off the record.

(Whereupon, the proceedings went off the record at 3:36 p.m.)

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UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Overview of the 10 CFR 50.46(b) Rulemaking

Presentation to ACRS Full Committee

June 8, 2011

Paul Clifford
Division of Safety Systems
Office of Nuclear Reactor Regulation

Meeting Agenda

1. 50.46(b) Rulemaking Overview
   - ACRS Interaction – Past, Present, Future
   - What's New

2. Regulatory Guides Supporting Rulemaking
   - PQD Test Protocols
   - Breakaway Test Protocols
   - Analytical Limits

3. Industry Testing and Round-Robin

Rulemaking Objectives*

- Following Commission directive, develop a performance-based rule which enables licensees to use advanced cladding materials without needing an exemption.
  - Replace prescriptive criteria with performance-based regulatory requirements.
  - Expand applicability beyond “zircaloy or ZIRLO”.

- Capture results of High Burnup LOCA Research Program.
  - Research identified new embrittlement mechanisms which necessitate rule changes.

* Slide from December 2008 ACRS Full Committee Meeting

ACRS Interactions – Past

ACRS briefed on technical basis and rulemaking strategy (December 4, 2008):

- Existing regulatory criteria (2200ºF, 17% ECR) need to be revised based on key research findings on cladding embrittlement:
  - Hydrogen-enhanced prior-beta layer embrittlement.
  - Cladding ID oxygen ingress.
  - Breakaway oxidation.
- Prescriptive criteria would be replaced with performance-based requirements.
  - PQD and breakaway test procedures would be provided in future Regulatory Guides.
  - ANPR would be issued to solicit stakeholder input on specific topics.

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ACRS Interactions – Past (cont.)

ACRS Letter (ML083460310, December 2008):

CONCLUSIONS AND RECOMMENDATIONS

- There are sufficient data and understanding of the cladding embrittlement phenomena to justify and proceed with rulemaking.
- The rule should include the proposed optional testing program to allow licensees to demonstrate compliance with post-quench-ductility (PQD) criteria on an alloy-specific and temperature-specific basis.
- A round robin test program would be beneficial in the validation of the test procedures used to demonstrate compliance with PQD and breakaway-oxidation criteria.

Recent Progress

1. ANPR issued, public comments received and addressed.

2. PQD and breakaway empirical database expanded.

3. Specific requirements (e.g.,1% plastic strain) moved from rule to RGs.

4. Supporting draft RGs developed

New Items

1. Developed draft Generic Letter and alternate industry initiative to confirm interim plant safety.

2. Expanded technical basis for treatment of fuel rod burst region.

3. Considering expansion of rulemaking scope to include fuel fragmentation and dispersion.

⇨ Each item will be addressed in future ACRS briefings

ACRS Interactions – Future

ACRS SC / FC:

Draft RGs	- May / June 2011
Expanded Technical Basis	- June 2011 (No FC)
Proposed Rule Package	- Dec. 2011 / Feb. 2012
Final RGs	- TBD
Final Rule Package	- TBD

ACRS Interactions – Present

Expected Outcome of Today's Briefing:

1. Obtain concurrence to issue draft RGs for public comment.

2. Provide industry opportunity to brief ACRS on results of recent LOCA testing and planned round-robin.

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Overview of Regulatory Guidance to support Emergency Core Coolant System rulemaking

June 8, 2011

Michelle Flanagan
Division of Systems Analysis
Office of Nuclear Regulatory Research

Meeting Objective

To present the background, context and details of three Regulatory Guides which support Emergency Core Cooling System (ECCS) rulemaking revisions

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Background

- Fuel-cladding research program investigated the behavior of high-exposure fuel cladding under accident conditions
- New cladding embrittlement mechanisms identified and knowledge of previously identified mechanisms expanded
  - Hydrogen-enhanced embrittlement
  - Breakaway oxidation
  - Oxidation on inner cladding diameter due to fuel-cladding bond

Background

- Rulemaking initiated to revise ECCS acceptance criteria to reflect the research findings
- The revisions are also intended to develop performance-based features of 10 CFR 50.46

- Therefore, 10 CFR 50.46c calls for:
  - Material-specific analytical limits which account for material-specific burnup effects
  - ECCS performance consistent with avoiding measured breakaway behavior
  - Periodic testing for breakaway behavior

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Approach

These regulatory guides make it possible to revise 10 CFR 50.46c in a performance-based manner by:

- Providing a means of consistent, comparable generation of data to establish regulatory limits for peak cladding temperature (PCT) and oxidation
- Providing a means of consistent, comparable data generation to establish, and periodically confirm regulatory limits related to breakaway oxidation
- Providing a consistent means of using experimental data to establish regulatory limits
- Simplifying the staff's review process
- Reducing regulatory uncertainty, minimizing the costs associated with the implementation of the regulatory requirements proposed for 50.46c.

Approach

- DG-1261: Test procedure for measuring breakaway oxidation behavior and periodically confirming consistent behavior

- DG-1262: Testing procedure for measuring post-quench ductility using ring compression tests

- DG-1263: Developing analytical limits from measured data

Approach

Through stakeholder interaction and public comment, ensure that:

- the details and expectations of acceptable methods for measuring zirconium-based alloy behavior and developing limits are communicated effectively and completely
- measured behavior is expected to be repeatable within a laboratory
- measured behavior is expected to be repeatable between laboratories
- analytical limits will be developed consistently across fuel designs

Context

Relationship to rule language

DG-1263

To ensure that the zirconium-alloy cladding material's susceptibility to breakaway oxidation is beyond the realm of postulated LOCA core temperature excursions, the total accumulated time that the cladding is predicted to remain above a temperature at which the zirconium alloy has been shown to be susceptible to this phenomenon shall not be greater **than a specified and acceptable limit** which corresponds to the measured onset of breakaway oxidation for the zirconium-alloy cladding material **based on an acceptable experimental technique**. The onset of breakaway oxidation shall be measured periodically on as-manufactured cladding material and any changes in the time to the onset of breakaway oxidation shall be reported at least annually as specified in § 50.4 or § 52.3 of this chapter, as applicable, and shall also be addressed in accordance with § 21.21 of this chapter.

DG-1261

Context

Relationship to rule language

DG-1263

Specified and acceptable analytical limits on peak cladding temperature and time at elevated temperature shall be established which correspond to the measured ductile-to-brittle transition for the zirconium-alloy cladding material **based on an acceptable experimental technique**. The calculated maximum fuel element temperature and time at elevated temperature shall not exceed the established analytical limits.

If the peak cladding temperature established to preserve cladding ductility is lower than the 2200º F limit specified in (d)(1)(i), then the lower temperature shall be used in place of the 2200º F limit.

DG-1262

“Acceptable experimental techniques” *to measure ductile-to-brittle transition for the zirconium-alloy cladding material*

Rule language provides flexibility in experimental technique used to measure the ductile-to-brittle transition

The experimental technique used would be submitted to NRC for review and approval

Alternatively, DG-1262 could be used as an experimental technique already reviewed and approved by NRC

The experimental technique used in DG-1262 is ring compression testing

Other methods, such as three point bending, have been shown to yield comparable results in the measurement of the ductile-to-brittle transition, and could be pursued by applicants

"Acceptable experimental techniques" *to measure ductile-to-brittle transition for the zirconium-alloy cladding material*

Ring Compression testing (RCT) and three point bend testing (3PBT) has been shown to yield comparable results in the measurement of the ductile-to-brittle transition.

"As some RCT curves are difficult to interpret, we also performed 3PBT. The curves are remarkably similar and the conclusions are the same (Fig. 23)."

Page 23 of J.-C. Brachet, V. Vandenberghe-Maillot, L. Portier, D. Gilbon, A. Lesbros, N. Waeckel, and J.-P. Mardon, "Hydrogen Content, Preoxidation, and Cooling Scenario Effects on Post-Quench Microstructure and Mechanical Properties of Zircaloy-4 and M5® Alloys in LOCA Conditions," J. ASTM Intl., Vol. 5, No. 5 (2008).

CEA also performed microhardness tests and very detailed imaging (EPMA analysis and SEM Fractography) to support that "brittle" as determined from both RCTs and 3PBTs is confirmed by these post-quench methods. They also performed these analyses on "ductile" material.

In their PowerPoint presentation material presented at the June 24-28, 2007 ASTM meeting, they conclude:

"Results of RCTs and 3PBTs at 135°C are consistent with each other."

“Acceptable experimental techniques” *to measure ductile-to-brittle transition for the zirconium-alloy cladding material*

Data from Zr-4 material with ≈ 600 wppm, oxidized at 1200C, quenched from 800C

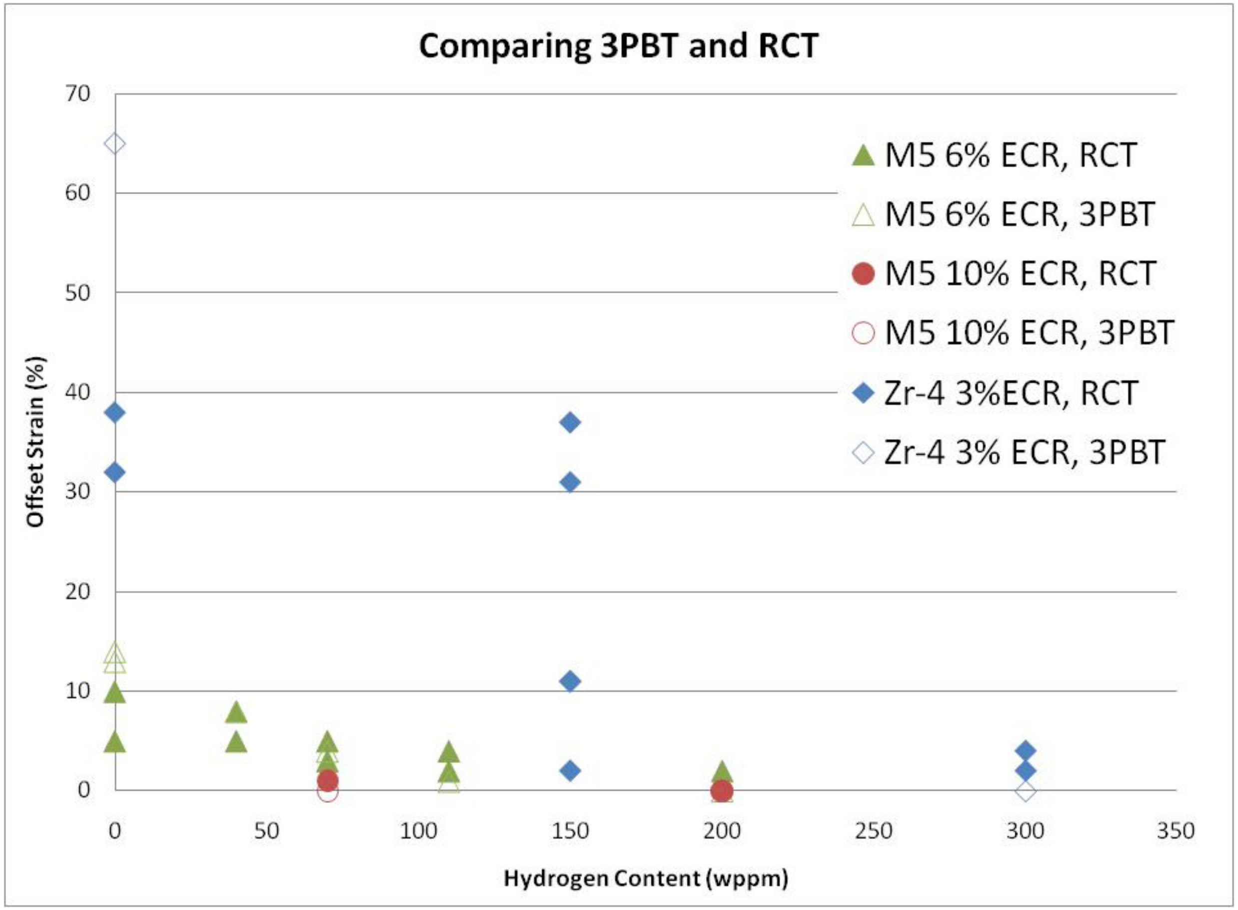
All results show brittle, or marginally ductile behavior.

Cooling Scenario	RCT	3PBT
DEZ 1 Slow Cool	0.73	0.15
	1.16	
DEZ 2 Slow Cool	1.57	0.15
10C/s	0.42	1.68

Data presented in: J.-C. Brachet, V. Vandenberghe-Maillot, L. Portier, D. Gilbon, A. Lesbros, N. Waeckel, and J.-P. Mardon, "Hydrogen Content, Preoxidation, and Cooling Scenario Effects on Post-Quench Microstructure and Mechanical Properties of Zircaloy-4 and M5® Alloys in LOCA Conditions,“ J. ASTM Intl., Vol. 5, No. 5 (2008).

“Acceptable experimental techniques”

to measure ductile-to-brittle transition for the zirconium-alloy cladding material



Data presented in: J.-C. Brachet, V. Vandenberghe-Maillot, L. Portier, D. Gilbon, A. Lesbros, N. Waeckel, and J.-P. Mardon, "Hydrogen Content, Pre Oxidation and Cooling Scenario Influences on Post-Quench Mechanical Properties of Zy-4 and M5® alloys in LOCA conditions – Relationship with the Post-Quench Microstructure," presented at the 15th ASTM Int. Symp. of Zirconium in the Nuclear Industry, June 24-28, 2007, Sunriver, Oregon, US

Schedule

- Three draft guides are now in inter-office concurrence
- Draft guides will be issued for public comment at the same time as the proposed rule is issued for public comment
- Draft guides will then follow standard revision and review process

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Protecting People and the Environment

Backup material

“Acceptable experimental techniques”

to measure ductile-to-brittle transition for the zirconium-alloy cladding material

Use of Ring Compression Testing (RCT):

Like the program that defined LOCA acceptance criteria implemented in 1973, NRC’s test program used RCTs to assess the oxidation and temperature limits at which embrittlement occurs. Staying close to the existing basis and emergency core cooling system computations was an important regulatory consideration.

U.S.NRC
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DG- 1261: Conducting Periodic Testing for Breakaway Oxidation Behavior

June 8, 2011

Michelle Flanagan
Division of Systems Analysis
Office of Nuclear Regulatory Research

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Context

Relationship to rule language

DG-1263

To ensure that the zirconium-alloy cladding material's susceptibility to breakaway oxidation is beyond the realm of postulated LOCA core temperature excursions, the total accumulated time that the cladding is predicted to remain above a temperature at which the zirconium alloy has been shown to be susceptible to this phenomenon shall not be greater **than a specified and acceptable limit** which corresponds to the measured onset of breakaway oxidation for the zirconium-alloy cladding material **based on an acceptable experimental technique**. The onset of breakaway oxidation shall be measured periodically on as-manufactured cladding material and any changes in the time to the onset of breakaway oxidation shall be reported at least annually as specified in § 50.4 or § 52.3 of this chapter, as applicable, and shall also be addressed in accordance with § 21.21 of this chapter.

DG-1261

Objective

DG-1261

The objective of this regulatory guide is to enable performance-based rule language in 10 CFR 50.46c by providing a means of consistent, comparable data generation to establish, and periodically confirm, regulatory limits related to breakaway oxidation for zirconium-based alloys.

Thereby:

(1) Simplifying the staff's review process
(2) Reducing regulatory uncertainty, minimizing the costs associated with the implementation of the regulatory requirements proposed for 50.46c.

Objective

DG-1261

Criteria for success:

(1) Through stakeholder interaction and public comment, it is determined that:
- the details and expectations of one acceptable method for measuring a zirconium-based alloy's breakaway oxidation behavior are communicated effectively and completely
- using the test procedures produces repeatable measurements within a laboratory
- using the test procedures produces consistent measurements between laboratories

(2) Therefore: Differences in measured values of time to breakaway behavior are a reflection of allowable differences in material behavior, and not the result of differences in experimental protocol.

Development of
DG-1261

- Captures the experimental technique used in NRC's LOCA research program
- Includes flexibility, where possible, to allow variation of equipment and procedures in use at other laboratories
- Draft of the procedure published for comment in conjunction with the "Advance Notice of Proposed Rulemaking (ANPR)" in August 2009
- The experimental procedure provided has been revised in consideration of the comments received in response to the ANPR.

Guidance

DG-1261

Establish the onset of breakaway oxidation

- Use experimental procedure in Appendix A
  - Test matrix defined which includes temperatures of interest and degree of replicate testing to characterize variability
- Provide experimental results as part of the documentation supporting the staff's review and approval of the new fuel design

Guidance

DG-1261

Periodic Testing

- Use experimental procedure in Appendix A
  - A reduced test matrix focuses on the temperature at which the minimum time to breakaway oxidation was measured and states that 5 repeat tests are sufficient if breakaway is not observed
- Demonstration that breakaway was not experienced can be linked to time of established analytical limit

Guidance

DG-1261

- Reporting results
  - Objective of periodic testing is to confirm that a cladding's susceptibility to breakaway oxidation has not been altered.
  - Therefore, it is acceptable to report only changes in the time to the onset of breakaway oxidation.
  - Results of periodic testing shall be provided within the annual reports "specified in § 50.4 or § 52.3 of this chapter, as applicable, and shall also be addressed in accordance with § 21.21 of this chapter"

U.S.NRC
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Protecting People and the Environment

DG- 1262: Testing for Postquench Ductility

June 8, 2011

Michelle Flanagan
Division of Systems Analysis
Office of Nuclear Regulatory Research

Context

Relationship to rule language

DG-1263

Specified and acceptable analytical limits on peak cladding temperature and time at elevated temperature shall be established which correspond to the measured ductile-to-brittle transition for the zirconium-alloy cladding material **based on an acceptable experimental technique**. The calculated maximum fuel element temperature and time at elevated temperature shall not exceed the established analytical limits.

If the peak cladding temperature established to preserve cladding ductility is lower than the 2200º F limit specified in (d)(1)(i), then the lower temperature shall be used in place of the 2200º F limit.

DG-1262

Objective

DG-1262

To enable performance-based rule language in 10 CFR 50.46c by providing a means of consistent, comparable data generation to establish regulatory limits on peak cladding temperature and time at elevated temperature that corresponds to the measured ductile-to-brittle transition for a specific zirconium-alloy cladding material.

Thereby:

(1) Simplifying the staff's review process
(2) Reducing regulatory uncertainty, minimizing the costs associated with the implementation of the regulatory requirements proposed for 50.46c.

Objective

DG-1262

Criteria for success:

(1) Through stakeholder interaction and public comment, it is determined that:
- the details and expectations of one acceptable method for measuring a zirconium-based alloy's post quench ductility behavior are communicated effectively and completely
- using the test procedures produces repeatable measurements within a laboratory
- using the test procedures produces consistent measurements between laboratories

(2) Therefore: Differences in measured values are a reflection of differences in material behavior, and not a result of differences in experimental protocol.

Development of *DG-1262*

- Captures the experimental technique used in NRC's LOCA research program
- Includes flexibility, where possible, to allow variation of equipment and procedures in use at other laboratories
- Draft of the procedure published for comment in conjunction with the "Advance Notice of Proposed Rulemaking (ANPR)" in August 2009
- The experimental procedure provided has been revised in consideration of the comments received in response to the ANPR.

Guidance

DG-1262

- Use experimental technique to measure the ductile-to-brittle transition for a Zr-based cladding alloy

  - Can be used for generating data for any zirconium-alloy cladding material
  - Can be used for generating data at peak oxidation temperatures less than 1200°C
  - Includes discussion of using the procedure for testing irradiated material

DG- 1263: Establishing Analytical Limits for Zirconium-Based Alloy Cladding

June 8, 2011

Michelle Flanagan
Division of Systems Analysis
Office of Nuclear Regulatory Research

Objective
DG-1263

To enable performance-based rule language in 10 CFR 50.46c by providing a consistent means of using experimental data to establish regulatory limits related to cladding embrittlement and the breakaway behavior of zirconium-based alloys during LOCA conditions.

Thereby:

(1) Simplifying of the staff's review process
(2) Reducing regulatory uncertainty, minimizing the costs associated with the implementation of the regulatory requirements proposed for 50.46c.

Objective
DG-1263

(1) Establish an acceptable analytical limit for time at elevated temperature for the materials tested in NRC's LOCA research program

(2) Provide Guidance on requirements for:

- New cladding alloys to demonstrate comparable performance with the established database and use the analytical limit provided in the guide
- New or existing cladding alloys to establish a zirconium-alloy-specific limit other than the limit provided in the guide
- Establishing analytical limits at peak oxidation temperatures less than 1,204 °C (2,200 °F).

(3) Provide guidance on establishing an acceptable analytical limit to demonstrate that ECCS performance precludes the occurrence of breakaway oxidation

Objective
DG-1263

Criteria for success:

(1) Through stakeholder interaction and public comment, it is determined that the expectations for establishing analytical limits on peak cladding temperature and time at elevated temperature under LOCA conditions are determined to be communicated effectively and completely

Guidance

DG-1263

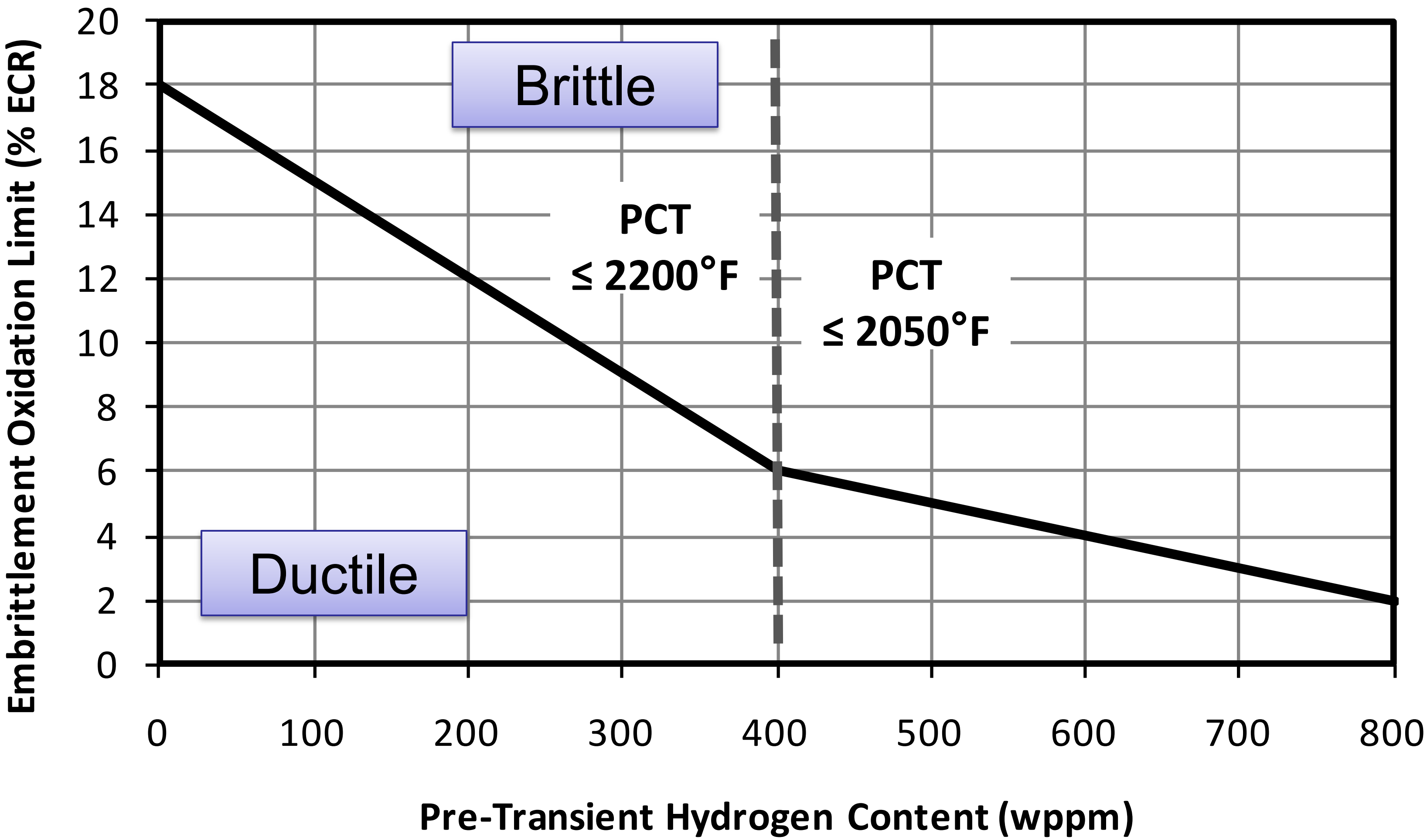
An acceptable analytical limit for time at elevated temperature for the materials tested in NRC's LOCA research program:

(1) Based on the data from NRC's LOCA research program
(2) Applicable to Zry-2, Zry-4, ZIRLO™, and M5
(3) PCT is related to limitations of experimental data
(4) Demonstrating that ECCS performance is such that local oxidation and peak cladding temperature are calculated below the analytical limits is acceptable to demonstrate compliance with 10 CFR 50.46c.

Guidance

DG-1263

Acceptable analytical limit for time at elevated temperature for the materials tested in NRC's LOCA research program



Guidance
DG-1263

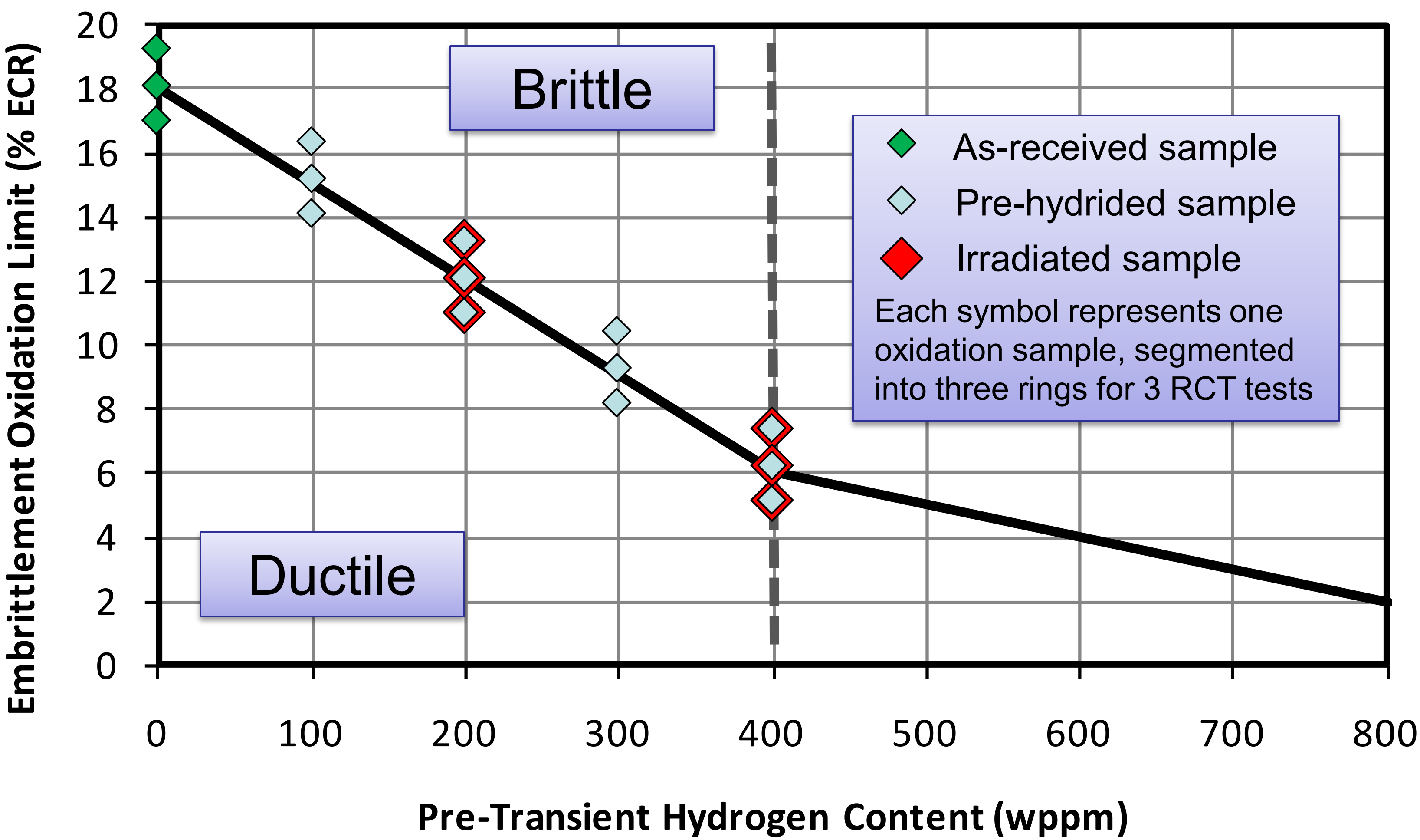
Demonstrating comparable performance for new cladding alloys:

(1) Focus on confirm that the transition to brittle behavior does not take place at a lower equivalent cladding reacted (ECR) than the provided limit
(2) Methodology includes testing of as-received, prehydrided, and irradiated material
(3) Methodology uses the experimental procedure in DG-1262 to generate RCT data
(4) Experimental results submitted as part of the documentation supporting the NRC staff's review and approval of the new fuel design
(5) Demonstrating that ECCS performance is such that local oxidation and peak cladding temperature are calculated below the analytical limit is acceptable to demonstrate compliance with 10 CFR 50.46c.

Guidance
DG-1263

Demonstrating comparable performance for new cladding alloys

an acceptable test matrix for a cladding material that is anticipated to have a maximum hydrogen content of 400-wppm hydrogen at end of life



Guidance

DG-1263

Establishing Alloy-Specific Limits or Limits at a PCT Lower than 2,200°F:

(1) Methodology is designed to characterize a cladding alloy's embrittlement behavior through the entire spectrum of conditions expected during operation
(2) Methodology includes testing of as-received, prehydrided, and irradiated material
(3) Methodology uses the experimental procedure in DG-1262 to generate RCT data
(4) Experimental results submitted as part of the documentation supporting the NRC staff's review and approval of the new fuel design
(5) Demonstrating that ECCS performance is such that local oxidation and peak cladding temperature are calculated below the analytical limit is acceptable to demonstrate compliance with 10 CFR 50.46c.

Guidance

DG-1263

Establishing Analytical Limits for Breakaway Oxidation:

(1) Provide experimental results for testing for breakaway oxidation behavior
(2) Methodology uses the experimental procedure in DG-1261 to generate data
(3) Establish time limit for the total accumulated time that the cladding may remain above 650 °C as part of the documentation supporting the NRC staff's review and approval of the new or existing fuel design
(4) Applicants may elect to establish the analytical limit for breakaway oxidation with conservatism relative to the measured minimum time (i.e., reduce the time) to the onset of breakaway oxidation
(5) Demonstrating that ECCS performance is such that the total accumulated time that the cladding is predicted to remain above a temperature at which the zirconium alloy has been shown to be susceptible to this phenomenon is not greater than the proposed limit is acceptable to demonstrate compliance with 10 CFR 50.46c.

Guidance
DG-1263

Other topics covered:

(1) Qualification of Hydrogen Pickup Models
- Submit PIE data and a hydrogen update model as part of the documentation supporting the NRC staff's review and approval of the new or existing fuel design

(2) Accounting for Uncertainty and Variability in Hydrogen Content
- Uncertainty should be quantified
- Allowable CP-ECR based on predicted peak circumferential average hydrogen content for the individual rod

(3) Application in the Rupture Region
- define the cladding thickness as the cladding cross-sectional area divided by the cladding circumference, taken at a horizontal plane at the elevation of the rupture
- calculate two-sided oxidation using the CP correlation

Guidance

DG-1263

Other topics covered:

(4) Accounting for Double-Sided Oxidation Due to the Fuel-Cladding Bond Layer

- One acceptable approach would be to calculate two-sided local oxidation for fuel rods with a local (nodal) exposure beyond 30 GWd/MTU
- A different threshold may be proposed by a licensee and provided as part of the documentation supporting the NRC staff's review and approval of the new or existing fuel design
- A different threshold could be supported by metallographic images of bonding layers as a function of burnup

(5) Breakaway Oxidation Analytical Limits

- identify the limiting combination of break size, break location, and initial conditions and assumptions that maximize the total accumulated time
- Operator actions can be credited

Extended Example for DG-1263

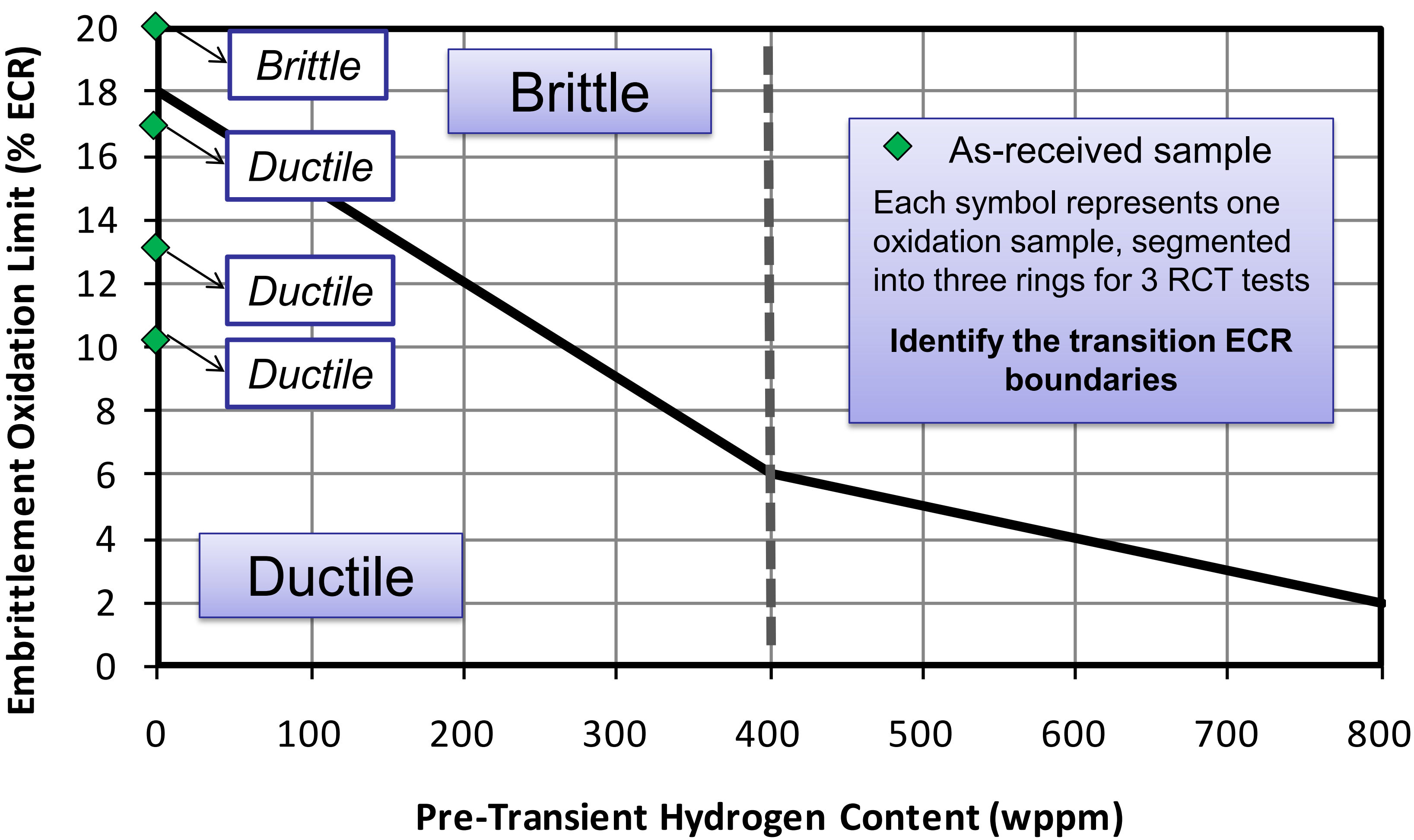
- The following slides depict the extent of testing required for establishing an alloy specific limit or a limit at a lower temperature.
- The example assumes a EOL [H] content of 400 wppm
- For illustration, the figures declare some points “brittle” or “ductile” only to show how the move to the next step is dictated by the previous measurements.

Guidance

DG-1263

Establishing Alloy-Specific Limits or Limits at a PCT Lower than 2,200 °F

an acceptable test matrix for a cladding material that is anticipated to have a maximum hydrogen content of 400-wppm hydrogen at end of life



Guidance

DG-1263

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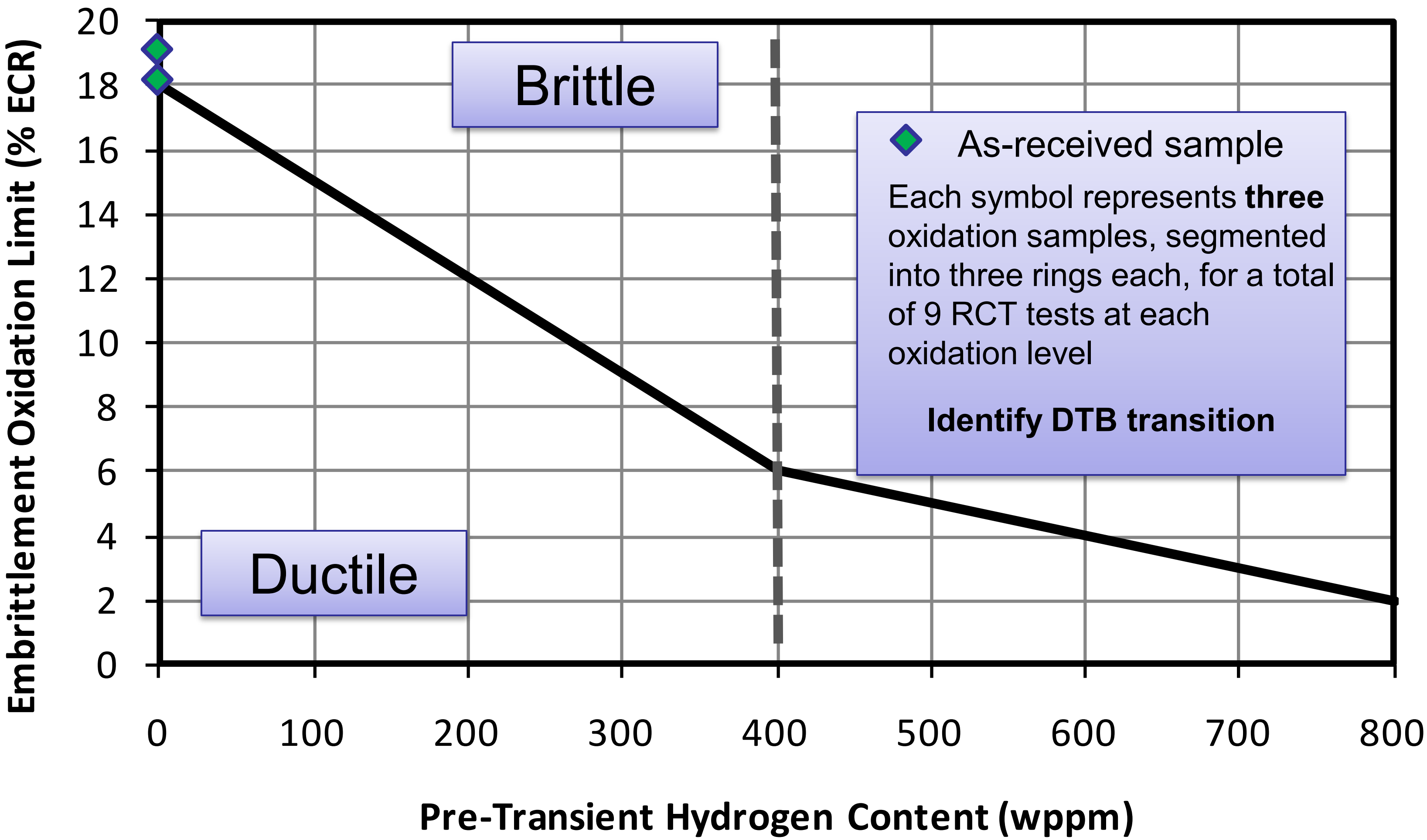

Guidance
DG-1263

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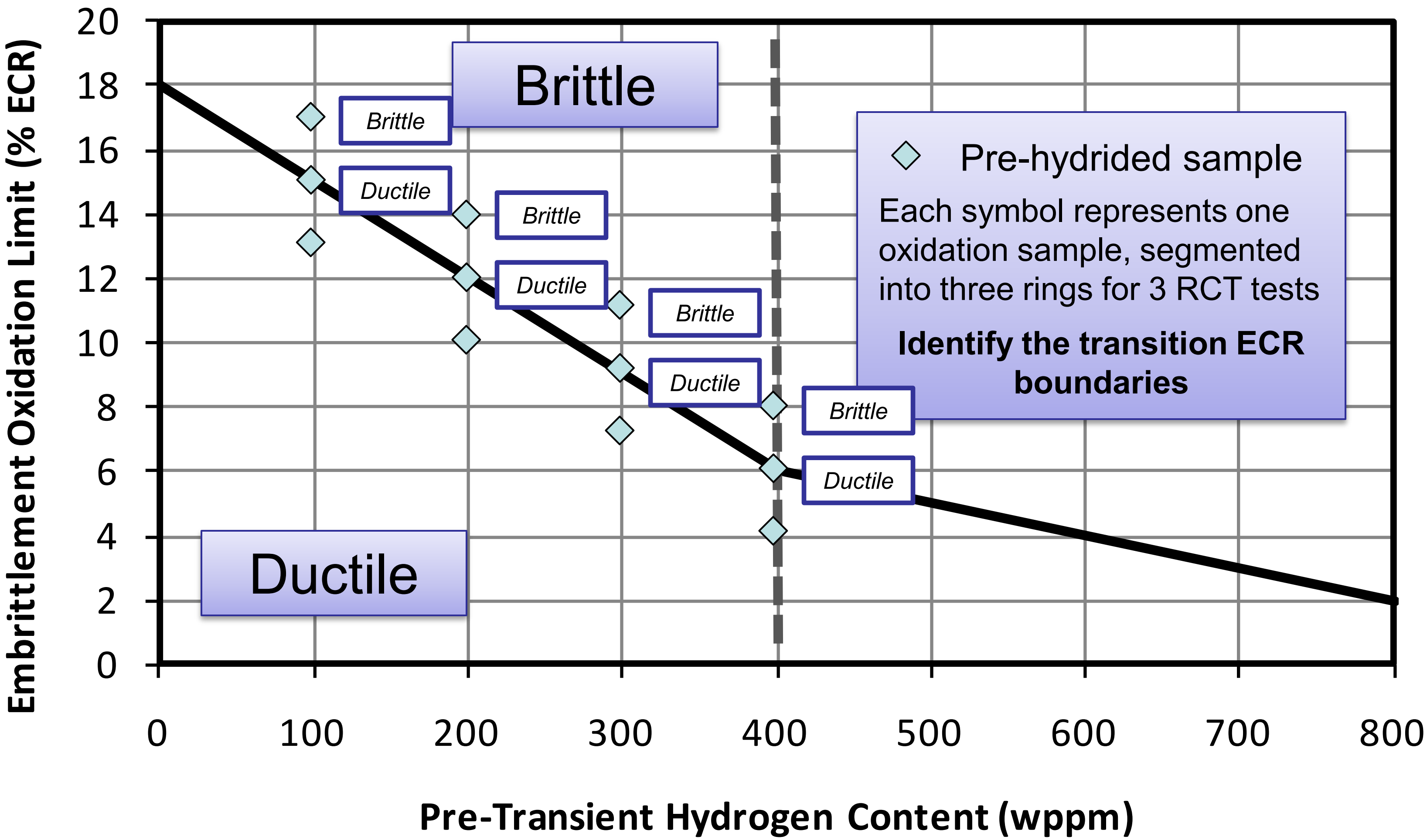

Guidance

DG-1263

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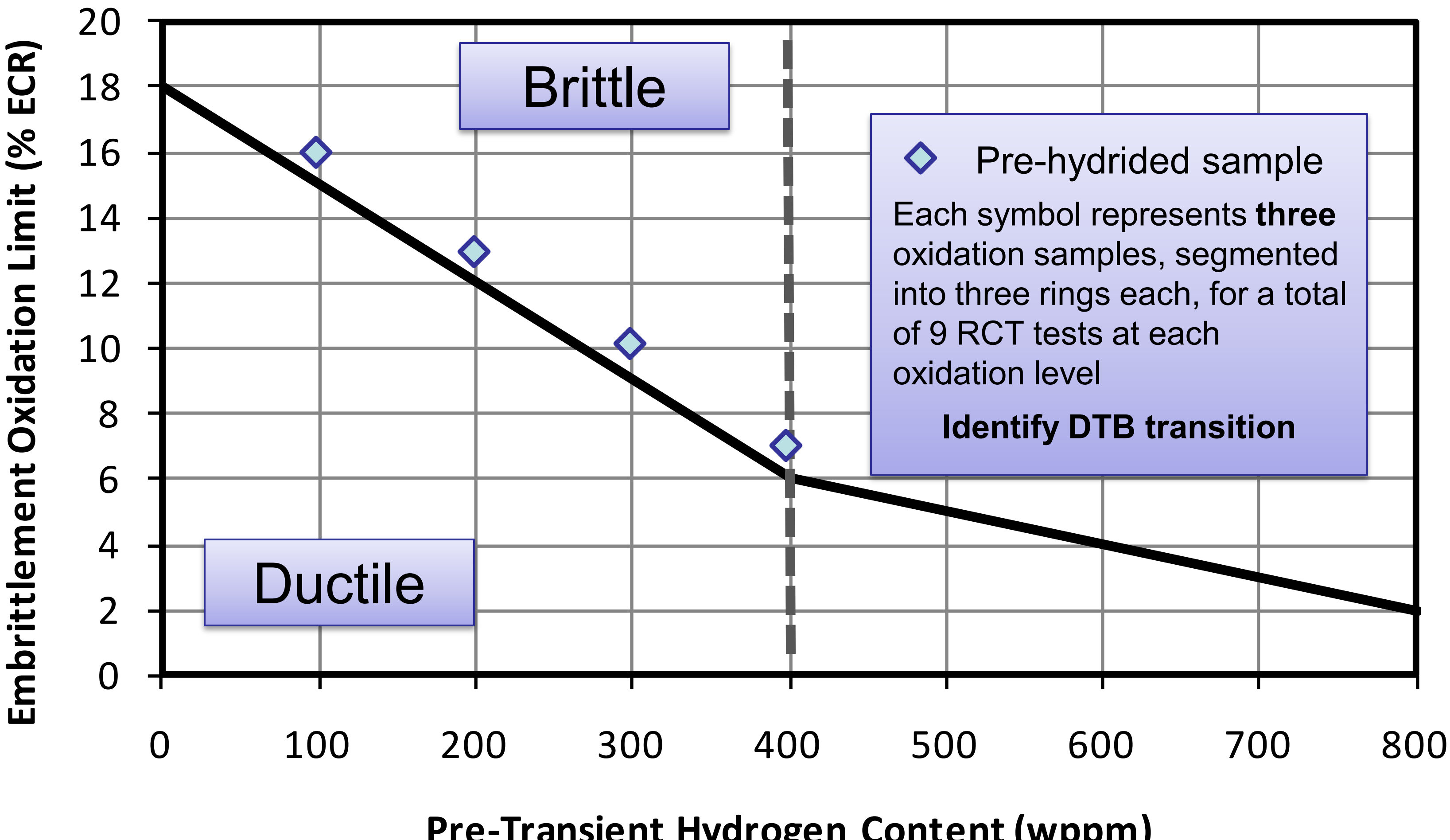

Guidance

DG-1263

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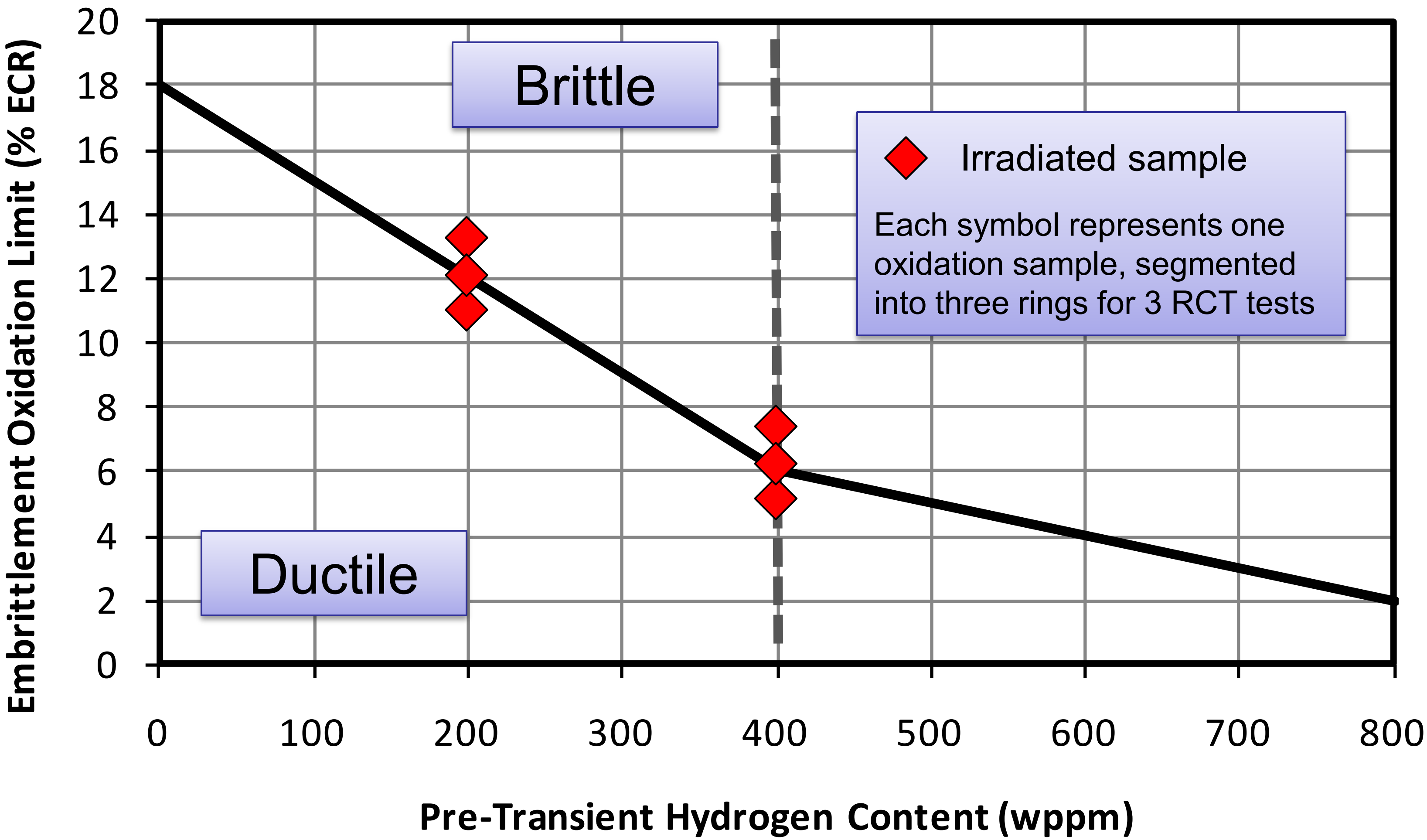

ELECTRIC POWER RESEARCH INSTITUTE

Industry LOCA Test Plans and Results

Ken Yueh
Senior Project Manager

ACRS Subcommittee Meeting
June 8th, 2011

Motivations for Industry LOCA Research Efforts

- Research data used as the basis for the LOCA rule were generated or applied in a conservative condition/manner
  - Many plants do not operate near the limiting conditions
  - Some phenomena have not been fully evaluated
- EPRI has sponsored several complementary test programs to fill some of the gaps
  - To better understand fuel performance under more realistic conditions

Presentation Outline

- Preliminary high temperature oxidation test results
- Inner diameter oxygen pickup (two-sided oxidation)
  - Fuel pellet interaction
  - Impact of limited ID oxygen source on PQD
- LOCA round robin test plans

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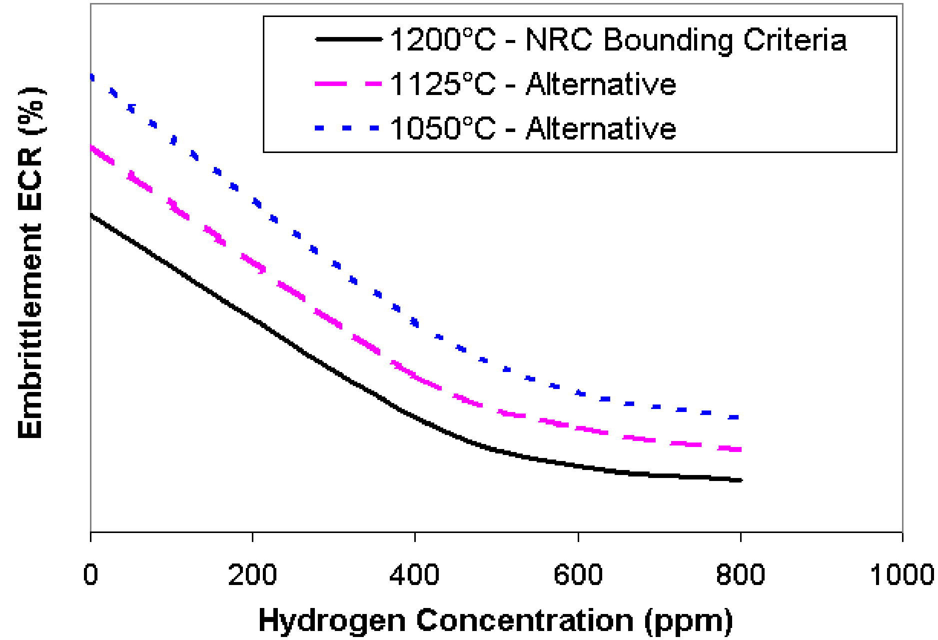
High Temperature Oxidation Preliminary Results

High Temperature Oxidation

- Motivation
  - ANL data indicates ECR accumulated at lower temperatures is not as detrimental to ductility for Zircaloy-4
- Test goals
  - Generate sufficient test data to propose alternative PQD criteria not tied to 1200°C
  - Attempt to demonstrate ECR is not reduced to zero at hydrogen > 600 ppm
  - Determine feasibility of developing an embrittlement model



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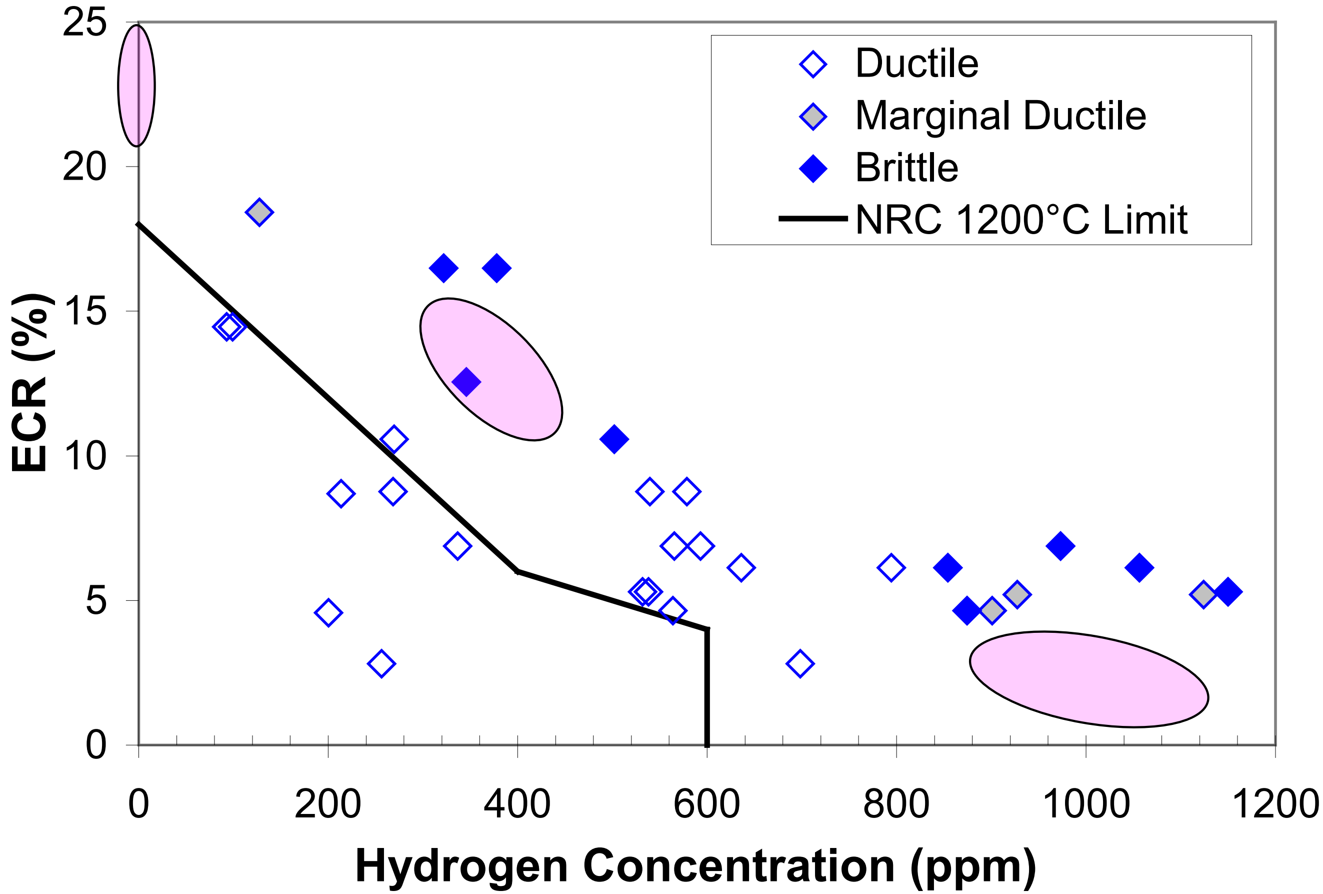
High Temperature Oxidation Preliminary 1050°C Test results

- A few additional tests planned to fill gaps (Summer 2011)



High Temperature Oxidation Test Summary

- Higher embrittlement ECR at lower oxidation temperatures is clearly demonstrated
  - The PCT of many plants and fuel will not reach 1200°C
- RCT based acceptance criteria is conservative
  - Clad at PCT only a short time

Recommendation

- Test data indicates alternative acceptance criteria can be justified
  - Family of embrittlement curves at different PCTs
  - Interpolation of acceptance criteria between PCTs and application of pin specific PCT
  - Use of model predictions should the phenomenon be successfully modeled

ID Oxygen Pickup

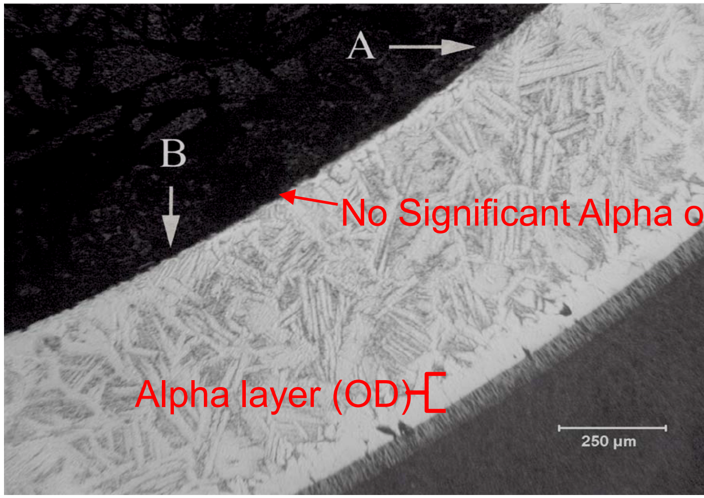
Two-sided Oxidation

- NRC announced the inclusion of two-sided oxidation away from the ballooned and burst region into rule
  - NRC cited similar ID and OD alpha phase thickness in the IFA650.5 test, PCT 1050°C, to justify two-sided oxidation

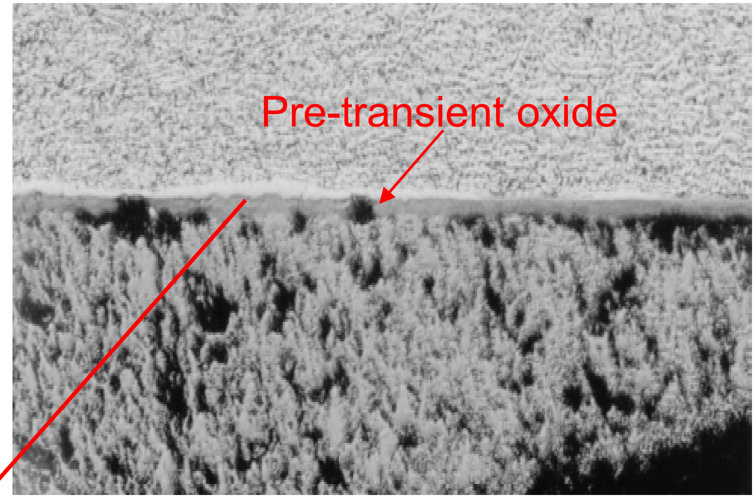
Alternative Hypothesis

- The ID surface oxygen pickup does not occur at the same rate or to the same extent as OD surface since ID oxygen source may be limited
  - Bonded fuel was suggested as a source of oxygen, but Limerick and Halden integral test results suggest it is limited
  - Internal oxygen source may be limited to the pre-transient oxide

Experimental Evidence

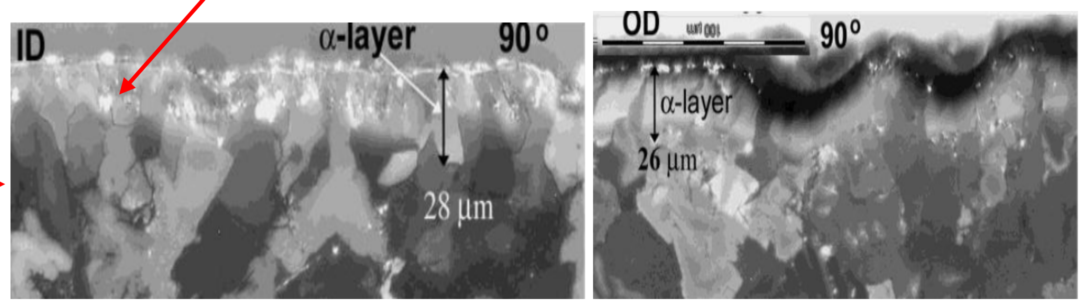


ANL Limerick Test, 50-60 GWD/MTU



Typical Bonded Fuel Structure

NRC basis for two-sided oxidation from Halden Report



Absence of significant observed fuel-clad reaction in both Halden and ANL tests suggests oxygen transfer from bonded fuel is limited, and may be limited to the pre-transient oxide

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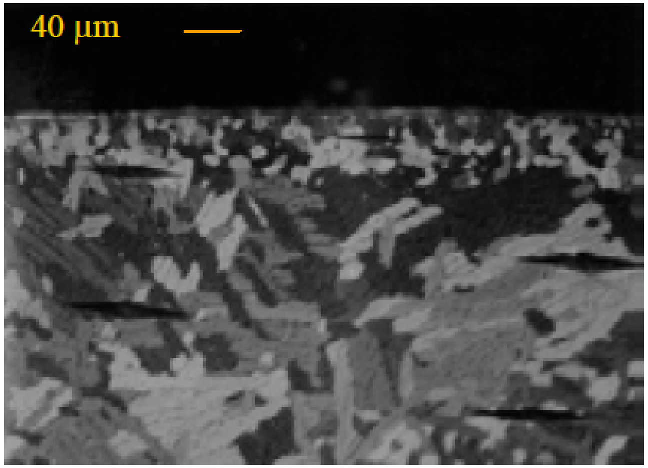
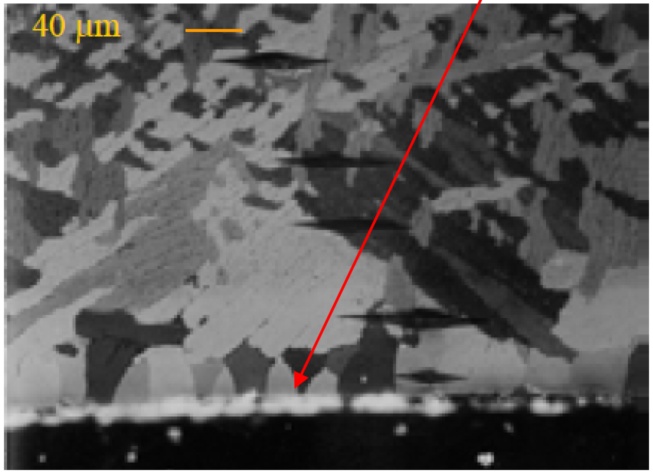
Fuel-Clad Interaction Test

- Halden IFA-650.5 test temperature profile approximately simulated
  - Pre-oxidized clad to ~7 μm at 650°C, no fuel pellet
  - Oxygen stabilized alpha similar to Halden test observed



Outer Diameter



Inner Diameter

Result confirms a pre-transient ID oxide can supply oxygen to form an oxygen stabilized alpha layer as seen in IFA 650.5

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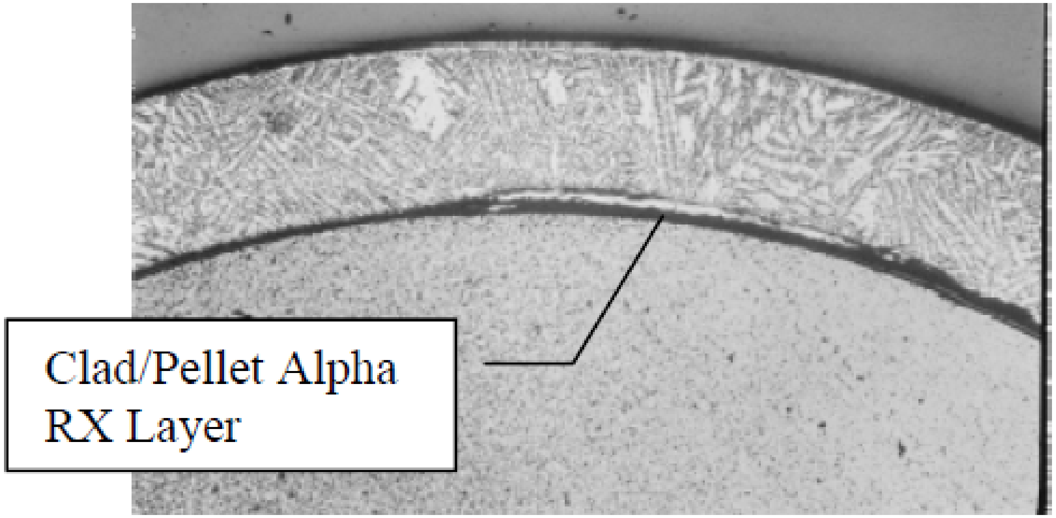
Fuel-Clad Interaction Test

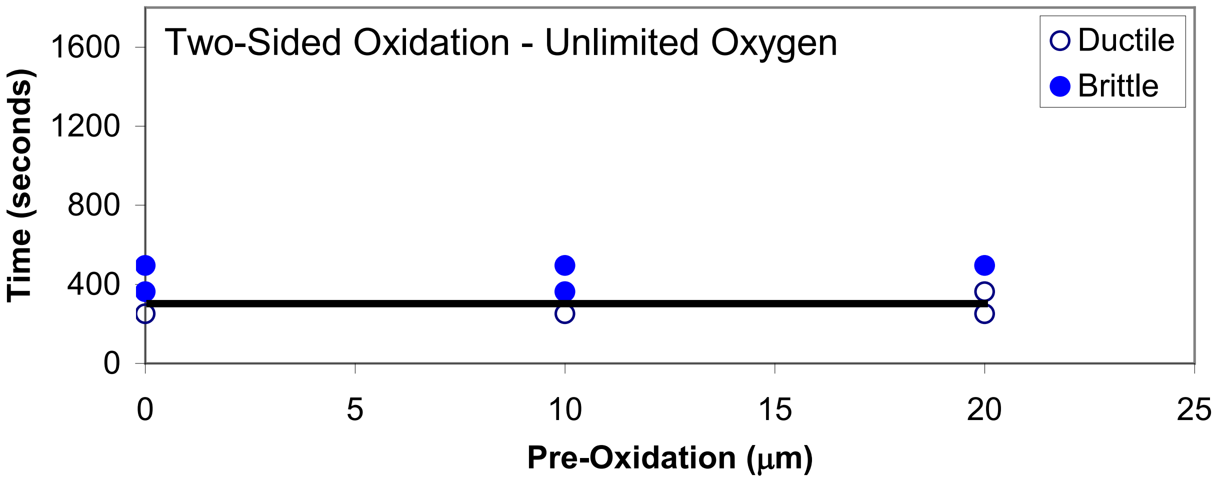
- Half of the test samples, independent of test contact pressure conditions, showed no pellet-clad reaction
- Minor localized pellet-clad reaction observed on some of the samples

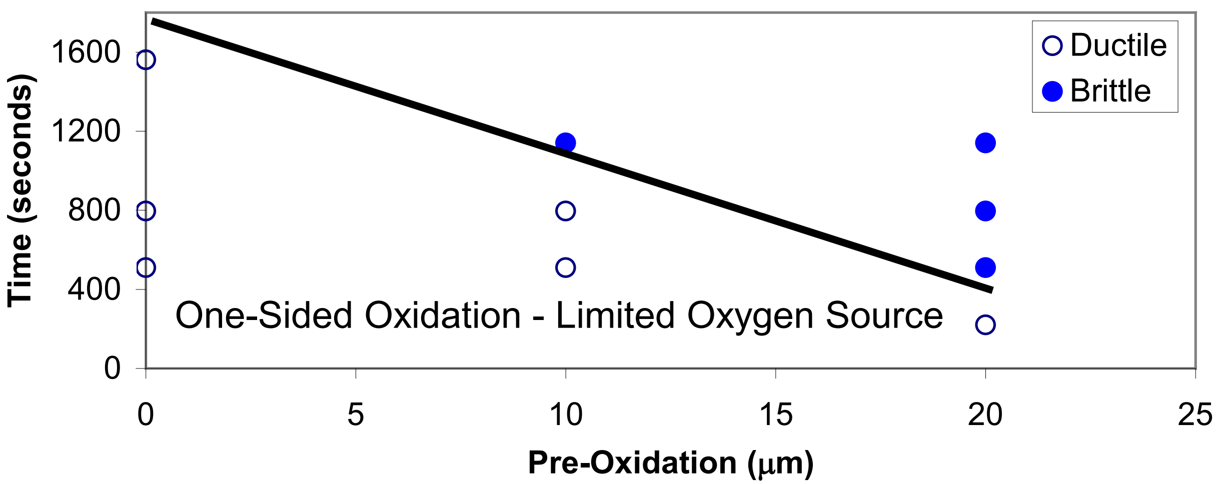


Reaction layer is minor and not directly observed in irradiated LOCA integral tests and therefore limited oxygen transfer from the fuel

Impact of Limited ID Oxygen Source on PQD

Impact of Limited Oxygen Source on PQD
Quantification of Impact on PQD – 1200°C





– Results within expectation
  - Time to ductility loss for one-sided oxidation samples increased significantly with no pre-oxidation, 362 to ~1800 seconds
  - Difference decreases with increasing pre-oxidation, ~400 vs. 362 seconds at 20 μm pre-oxidation

ID Oxygen Pickup Summary

- Oxygen stabilized alpha phase cited in IFA-650.5 could be generated from a pre-transient oxide rather than from fuel
- Limited potential for pellet-clad reaction
- Impact of limited ID oxygen source on PQD is less than un-restricted two-sided oxidation up to 20 μm of oxide
- Pre-oxidation slightly improves clad PQD performance

Recommendation

- Test demonstrated clad embrittlement is much reduced with limited ID oxygen source
  - Regulatory guidance should recognize this and allow for reduced impact under some conditions
    - e.g., 50% if pre-transient oxide is less than 10 μm

LOCA Round Robin

LOCA Round Robin
Project Goals

- Identify and evaluate sources of variation
  - Between laboratories (different procedures and methods)
  - Other experimental
- Generate sufficient test data to support ASTM test procedures

LOCA Round Robin Framework

- A minimum of five laboratory required
- All participating laboratories agreed to a set of high level requirements
  - Key technical requirements consistent with ANL recommendation
  - Common sets of tests using a common lot of material
  - Laboratories are free to use their own procedures
  - Basic data collection defined
  - Data generated are to be shared amongst all participating members

LOCA Round Robin
Test Matrix

Post Quench Ductility

- ANL-like temperature profile at 1200°C set point
- Determine embrittlement ECR, recommended ECR targets

Hydrogen Content (ppm)	Target CP ECR (%)		
As-Built	16	18	20
200	10	12	14
400	4	6	8
600	3	5	7

Breakaway Oxidation

- ANL recommended temperature profile
- Determine breakaway oxidation at 800 and 1000°C to within 500 seconds

LOCA Round Robin
Labs and Test Equipment

- Seven laboratories joined the Round Robin

Laboratory	H Charging Capability	Furnace Type	RCT Platform	Breakaway Online Instr.
AEKI	No	Resistance	Flat	Yes (hydrogen)
AREVA (via CEA)	Yes	Direct resistance		
GNF	Yes	Resistance		None
KAERI	Yes	Radiant	Flat	Yes (weight)
Oakridge	Yes	Resistance		
Studsvik*	No	Radiant		None
Westinghouse	Yes	Resistance	Flat	None

* May drop out of round robin because equipment moved into hot-cell

LOCA Round Robin
Milestones and Schedule

Step	Details	Schedule
1	Identify laboratories and solicit participation	Complete
2	Setup framework	Complete
3	Secure test material	Complete
4	Start test	On-going
5	Complete test	Summer 2011
6	Distribute data to participants and ASTM	TBD
7	Review data with the NRC and ASTM	TBD
8	Draft ASTM procedure	TBD
9	ASTM and NRC review procedure	TBD
10	Implement ASTM procedure	TBD

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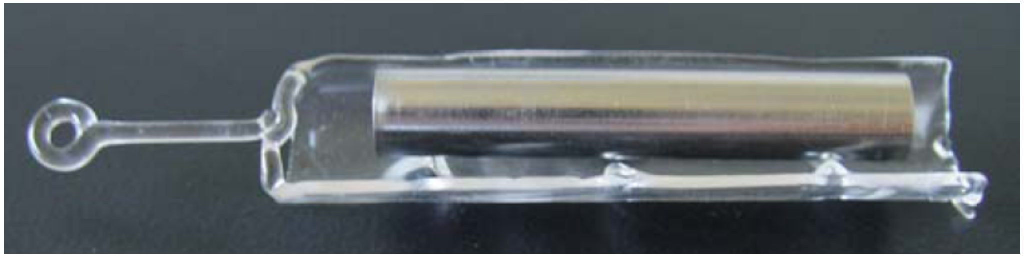
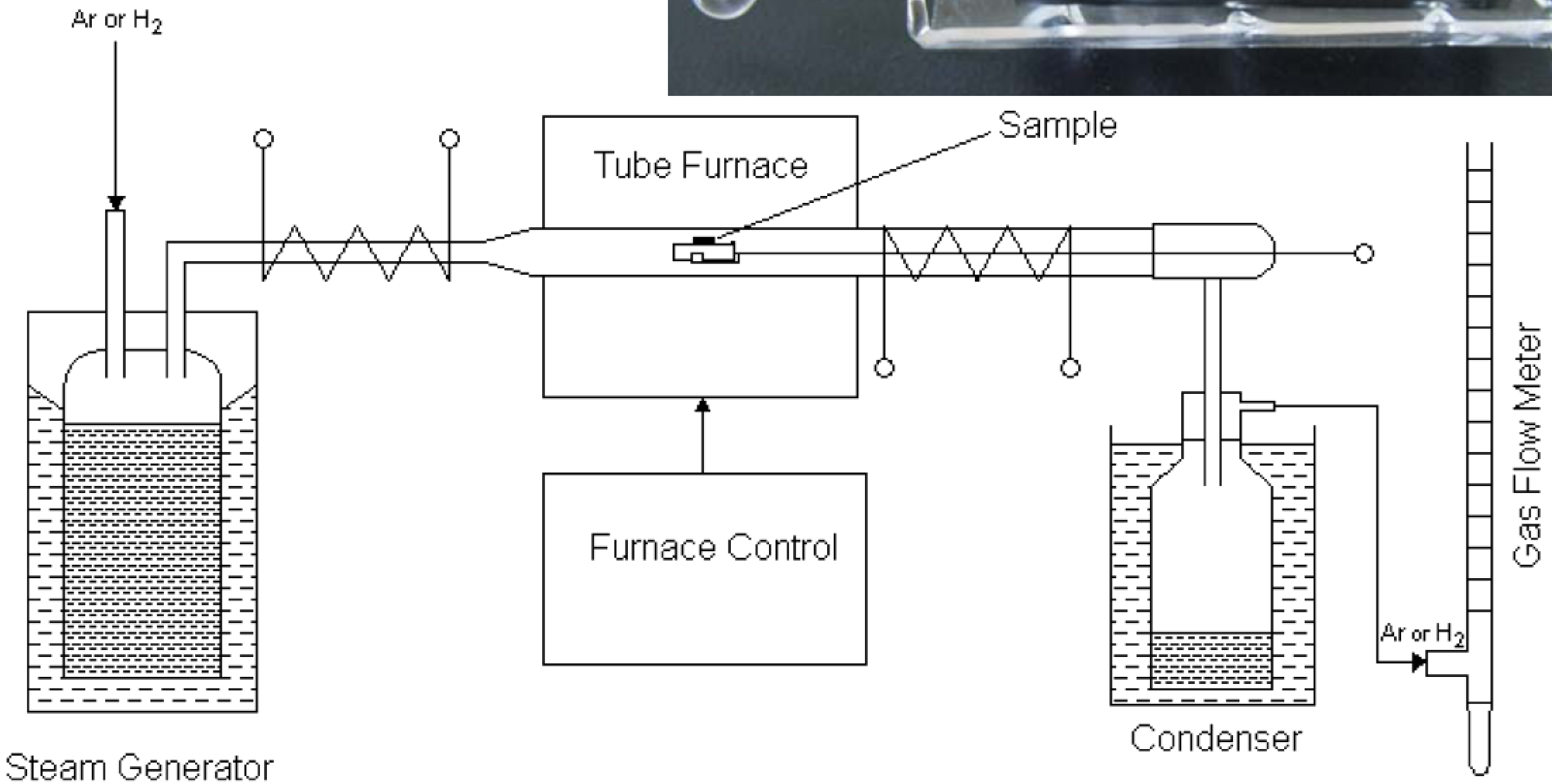
Together…Shaping the Future of Electricity

Impact of Limited Oxygen Source on PQD Test Setup

- Three zone horizontal furnace

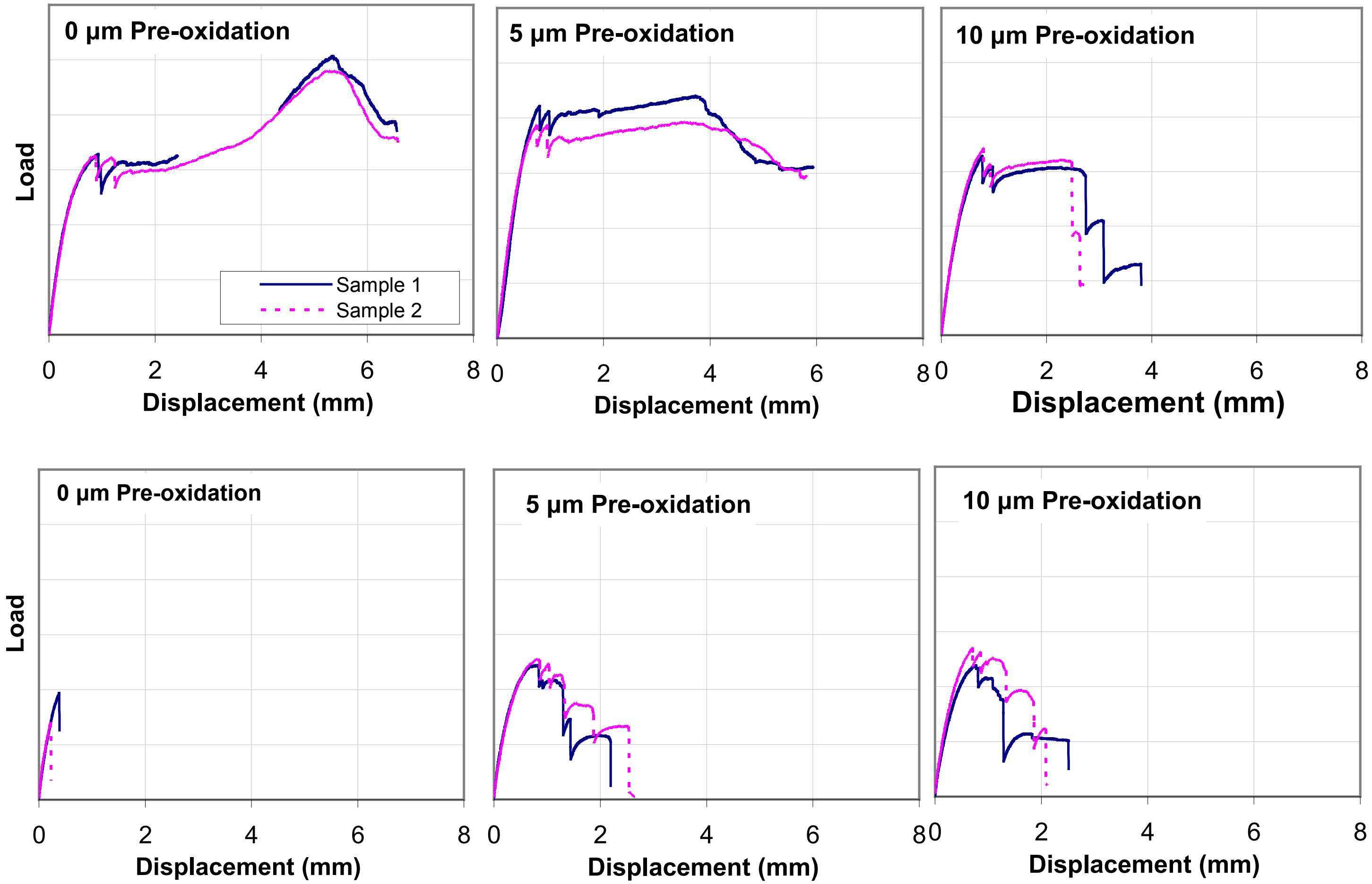




Impact of Limited Oxygen Source on PQD Results – 1200°C

- Sealed, one-sided
- 460s exposure

- Open, two-sided
- 475s exposure
- ~22 % ECR



Reduced impact on PQD from limited ID oxygen source Demonstrated

Hope Creek License Renewal

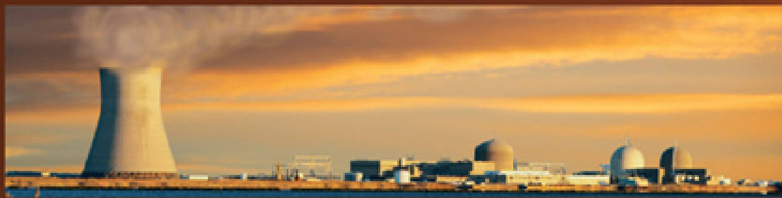
ACRS Full Committee
June 8, 2011

PSEG Nuclear LLC

Agenda

- Introduction – Paul Davison, Vice-President, Operations Support
- Topics of Interest
  - Drywell Air Gap Drains – Jim Stavely
  - Low Voltage Power Cables – John Hilditch
- Closing Comments – Paul Davison

PSEG Nuclear LLC



Hope Creek License Renewal

Topic of Interest:

Drywell Air Gap Drains

Jim Stavely

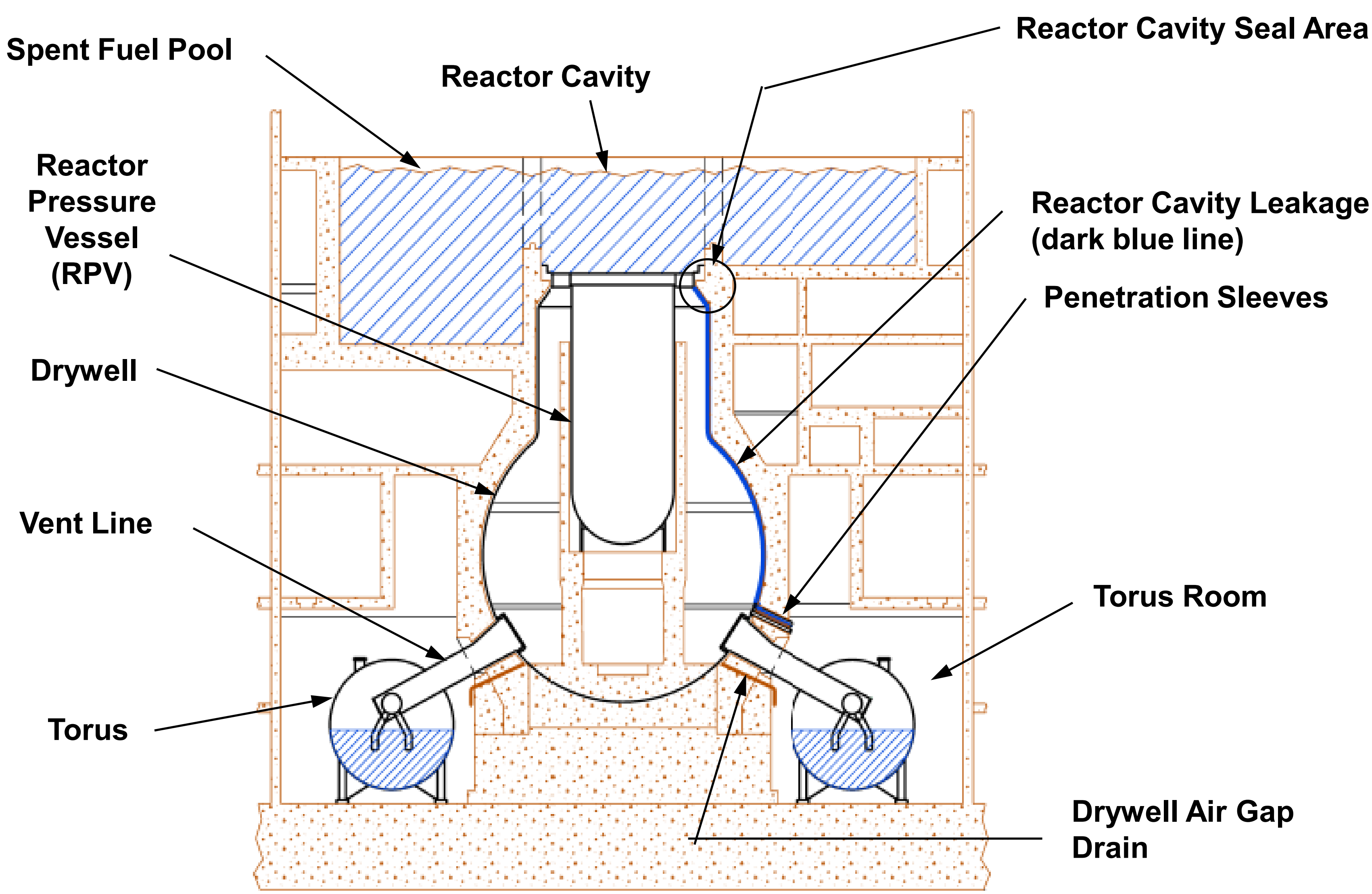
License Renewal Project

PSEG Nuclear LLC

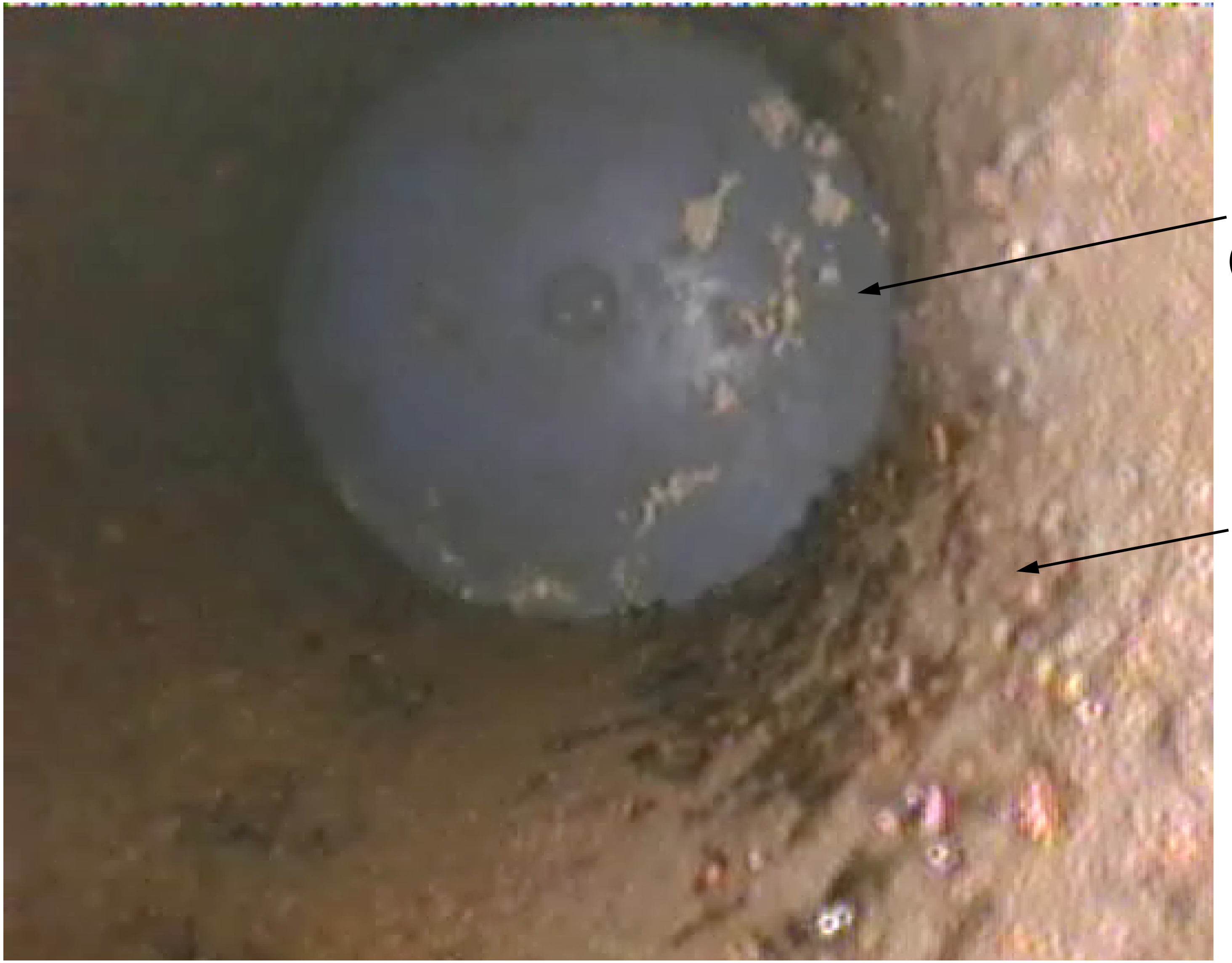
Containment – Drywell Shell

- Small reactor cavity leak
  - Leak observed during 2009 and 2010 refueling outages
- Blocked drywell air gap drains
  - Condition discovered during 2010 refueling outage
  - Condition investigated further in Spring 2011
- Boroscope examinations
  - No indication of drywell shell corrosion
  - Drywell shell coating intact and in good condition
  - No obstructions in drywell air gap
  - No water accumulation at bottom of drywell air gap
- UT thickness measurements
  - Approximately 350 thickness measurements in 2010 refueling outage
  - All but one area greater than nominal thickness
  - One area below nominal but above analyzed thickness & within construction tolerances

Containment - Refueling



Drywell Air Gap Drain



Plug
(typical of 4)

4” Drain
Pipe

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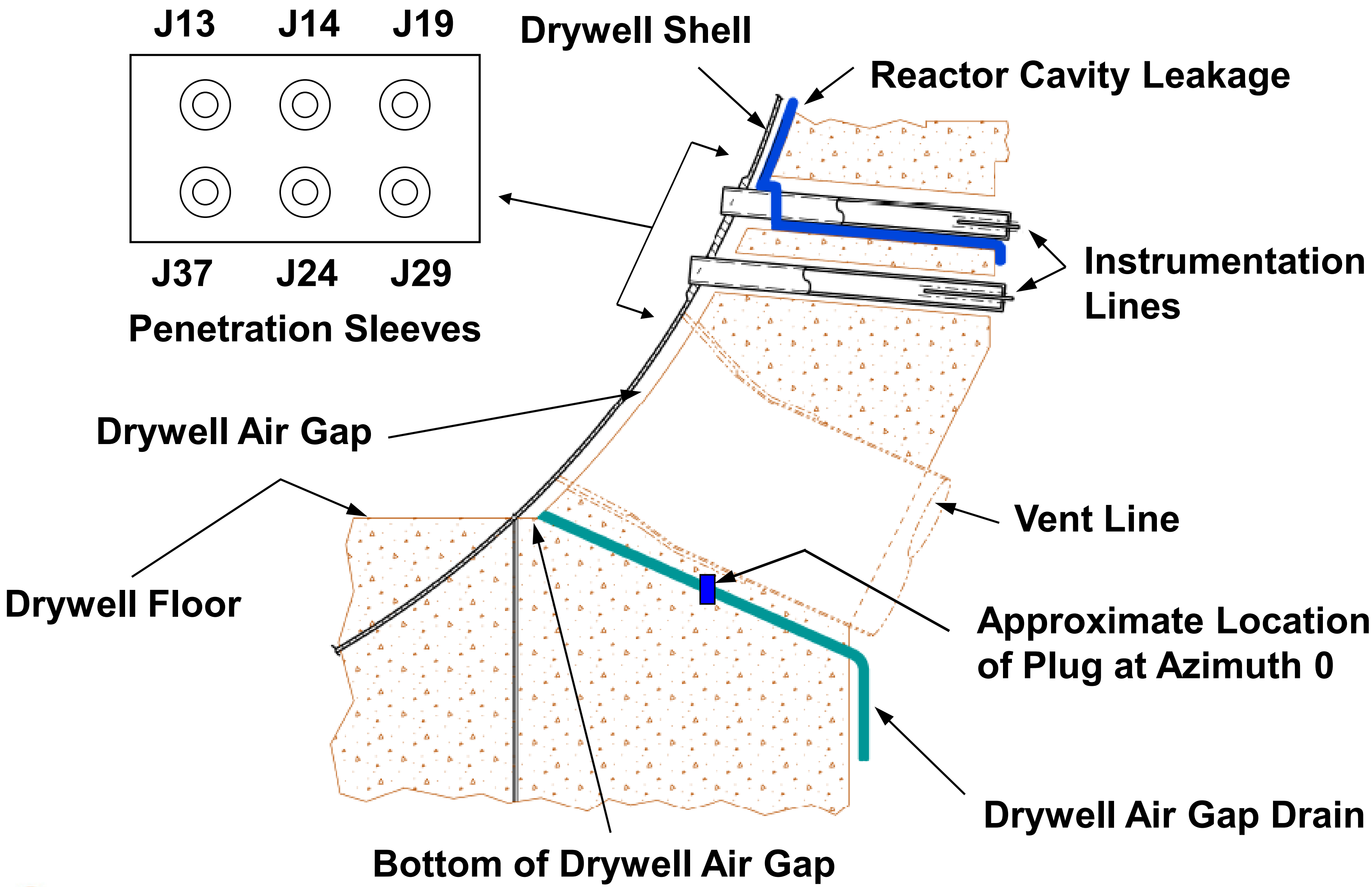
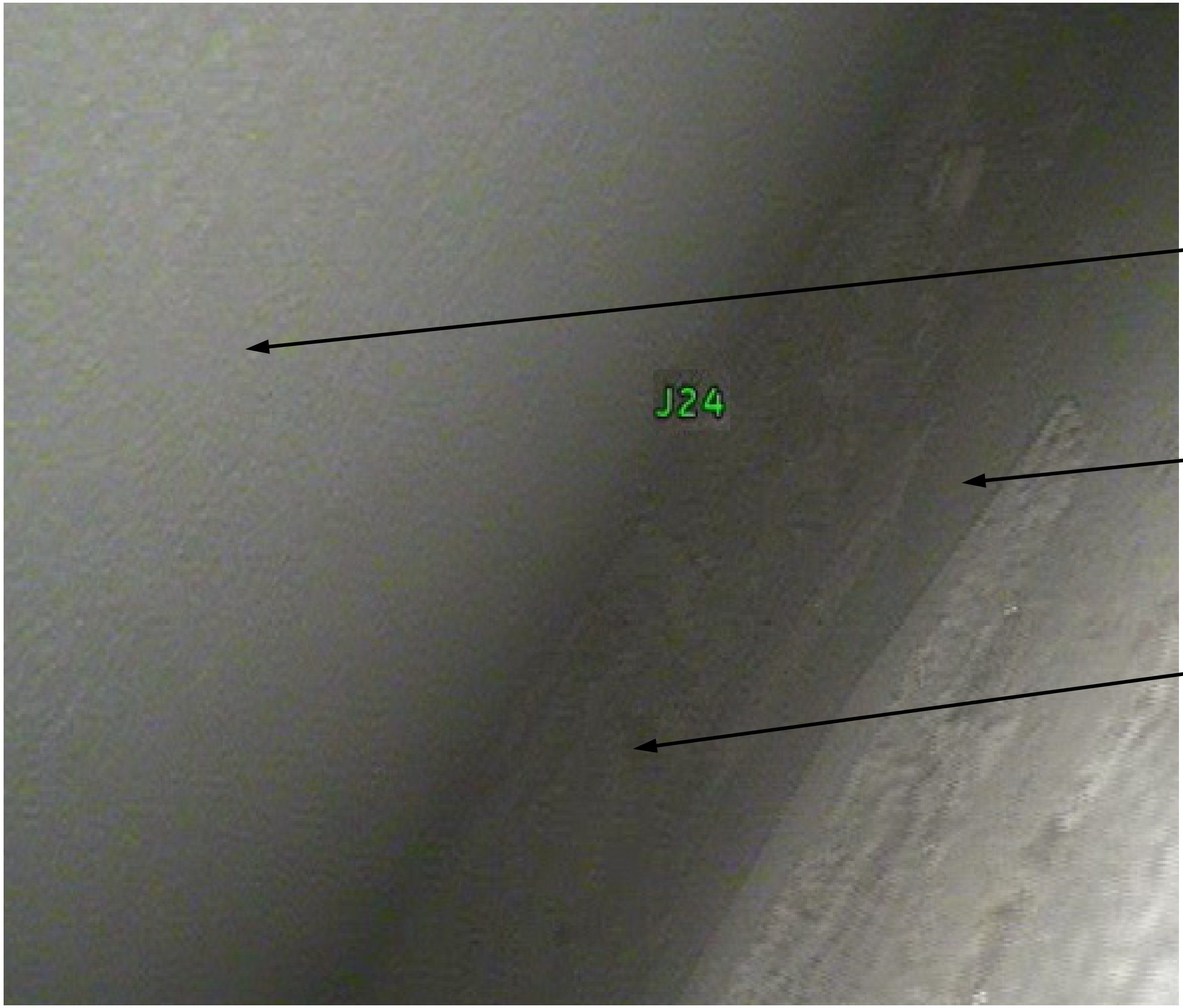
Nuclear LLC

Containment – Lower Drywell Area



Drywell Air Gap at Azimuth 225º



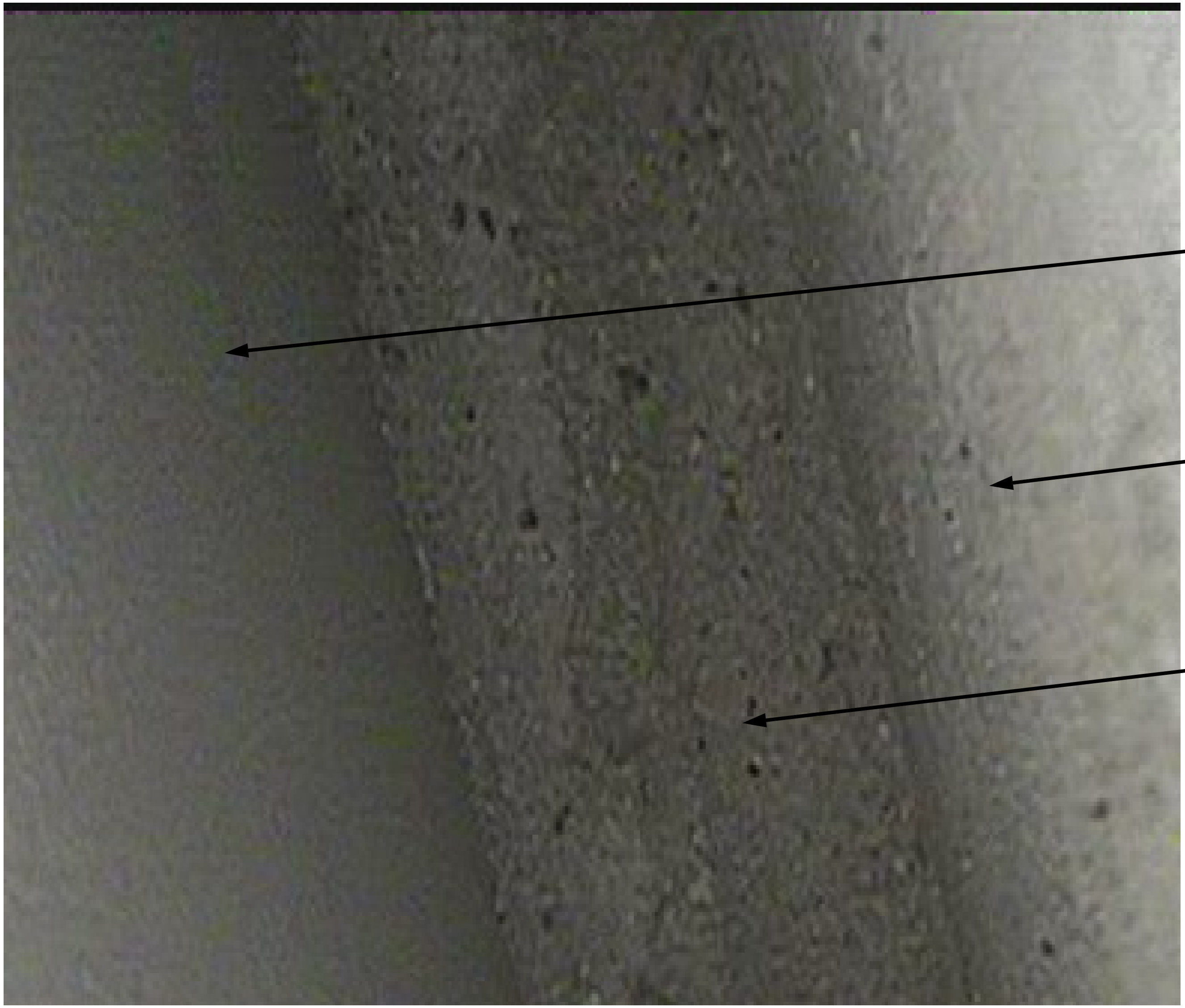
Drywell Shell

Concrete Shield Wall

Bottom of Drywell Air Gap

PSEG Nuclear LLC

Bottom of Drywell Air Gap at Azimuth 225º



Drywell Shell

Concrete Shield Wall

Bottom of Drywell Air Gap

PSEG Nuclear LLC

Commitments

- **Drainage capability will be established on or before June 30, 2015**
- **Prior to establishing drainage capability, the following will be performed each refueling outage:**
  - Boroscope examination of the bottom of the air gap for water accumulation or drywell shell corrosion
  - Until the reactor cavity leakage is repaired, monitoring of the J13 penetration area daily while the reactor cavity is flooded
  - Walkdown of the Torus Room daily while the reactor cavity is flooded to detect leakage from penetration sleeves
  - Ultrasonic thickness measurements
    - Below the J13 penetration area (Elevations 86'-11" to 93'-0")
    - Full circumference between bottom of the air gap up to vent header penetrations (Elevations 86'-11" to 88'-0")

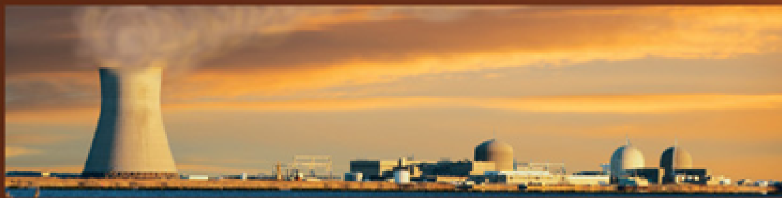
PSEG Nuclear LLC

Commitments (continued)

- **After establishing drainage capability, the following will be performed:**
  - Monitor air gap drains daily while reactor cavity is flooded
  - Until reactor cavity leakage is repaired:
    - Monitor the J13 penetration area daily while the reactor cavity is flooded
    - Perform daily walkdowns of the Torus Room while the reactor cavity is flooded to detect leakage from penetration sleeves
  - Perform ultrasonic thickness measurements during the next three refueling outages to confirm no ongoing corrosion or to establish a corrosion rate
- **Adverse conditions will be documented and addressed in the Corrective Action Program**

Conclusion

- The drywell shell is in good condition
- Until drainage capability from the bottom of the air gap is established, the drywell shell will be monitored using boroscope examinations and ultrasonic thickness measurements
- The small reactor cavity leak and the blocked drywell air gap drain lines are being managed effectively in the Corrective Action Program and in accordance with our license renewal commitments
- Drywell shell intended function will be maintained through the period of extended operation



Hope Creek License Renewal

Topic of Interest:

Low Voltage Power Cables

John Hilditch

License Renewal Project

PSEG Nuclear LLC

Hope Creek E3 Program

- Eight (8) low voltage (480 volt) power cables were added to the E3 Program
- Cables are 500 MCM, tri-plexed, unshielded, rated at 600 volts
- Cables are tested using the insulation resistance test which is the industry accepted test method
- Deterioration of insulation can be detected by trending insulation resistance measurements
- Results of 480 volt MCC post-maintenance insulation resistance tests show that the 480 volt power cables are in good condition

Hope Creek License Renewal

The Hope Creek Aging Management Programs will ensure continued safe operation through the Period of Extended Operation

PSEG Nuclear LLC

Advisory Committee on Reactor Safeguards (ACRS) License Renewal Full Committee

Hope Creek Generating Station (HCGS)

Safety Evaluation Report (SER)

June 8, 2011

Arthur Cunanan, Project Manager

Office of Nuclear Reactor Regulation

Presentation Outline

- Overview of the SER
- Drywell Air Gap Drains
- Inaccessible Power Cables
- Conclusion

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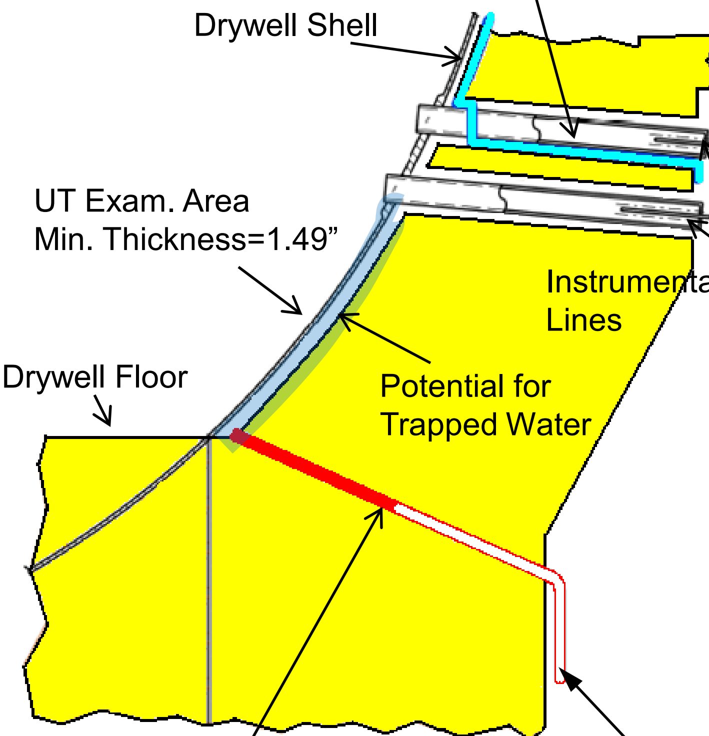
Overview (SER)

- The final SER was issued March 9, 2011
- Telephone conference call related to the drywell air gap drains on May 9, 2011
- ACRS Full Committee Meeting on May 12, 2011
- LRA supplement letter on May 19, 2011
- License Condition

SER Section 3

Reactor Cavity Leakage

- Recent findings by the applicant:
  - One air gap drain blocked 6 feet prior to reaching the drywell shell
  - Boroscope examination unable to detect exit port of the drain
  - Current configuration of the other three air gap drains unknown
- In order to ensure that the drywell air gap drains will be cleared and the drywell can perform its intended function, the staff will establish a license condition
- The applicant submitted a LRA supplement on May 19, 2011
- The LRA supplement revised the IWE program and commitments to verify the air gap drains are not degraded through boroscope and UT measurement examinations



License Condition for Reactor Cavity Leakage

The license condition requires the applicant to:

- Establish drainage of the drywell air gap drains on or before June 30, 2015
- Until drainage is established:
  - Perform boroscope and UT examinations every outage
  - Monitor penetration J13 for water leakage
  - Perform walkdown of torus room to detect leakage
  - Submit report to NRC after every outage
- After drainage is established:
  - Submit report to NRC on air gap drain configuration
  - Monitor penetration J13 for water leakage
  - Perform walkdown of torus room to detect leakage
  - Perform UT examination for the next three outages and submit report to NRC after every outage

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Inaccessible Power Cables (SER 3.0.3.1.20)

Question Related to Testing of Low Voltage Power Cables

- Applicant revised its program to expand the scope of Inaccessible Medium Voltage Cables AMP to include low voltage power cables (480 V to 2kV)
- Selection of appropriate test method depends on:
  - Cable characteristics
  - Installation/location
  - Service voltage and environment
  - Applicable aging mechanisms to be detected
- Hope Creek uses Tan δ testing on in-scope medium voltage cables and insulation resistance testing on in-scope low voltage power cables
- Hope Creek has no history of failures of in-scope inaccessible low and medium voltage power cables

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Conclusion

On the basis of its review, the staff determines that the requirements of 10 CFR 54.29(a) have been met for the license renewal of Hope Creek Generating Station.

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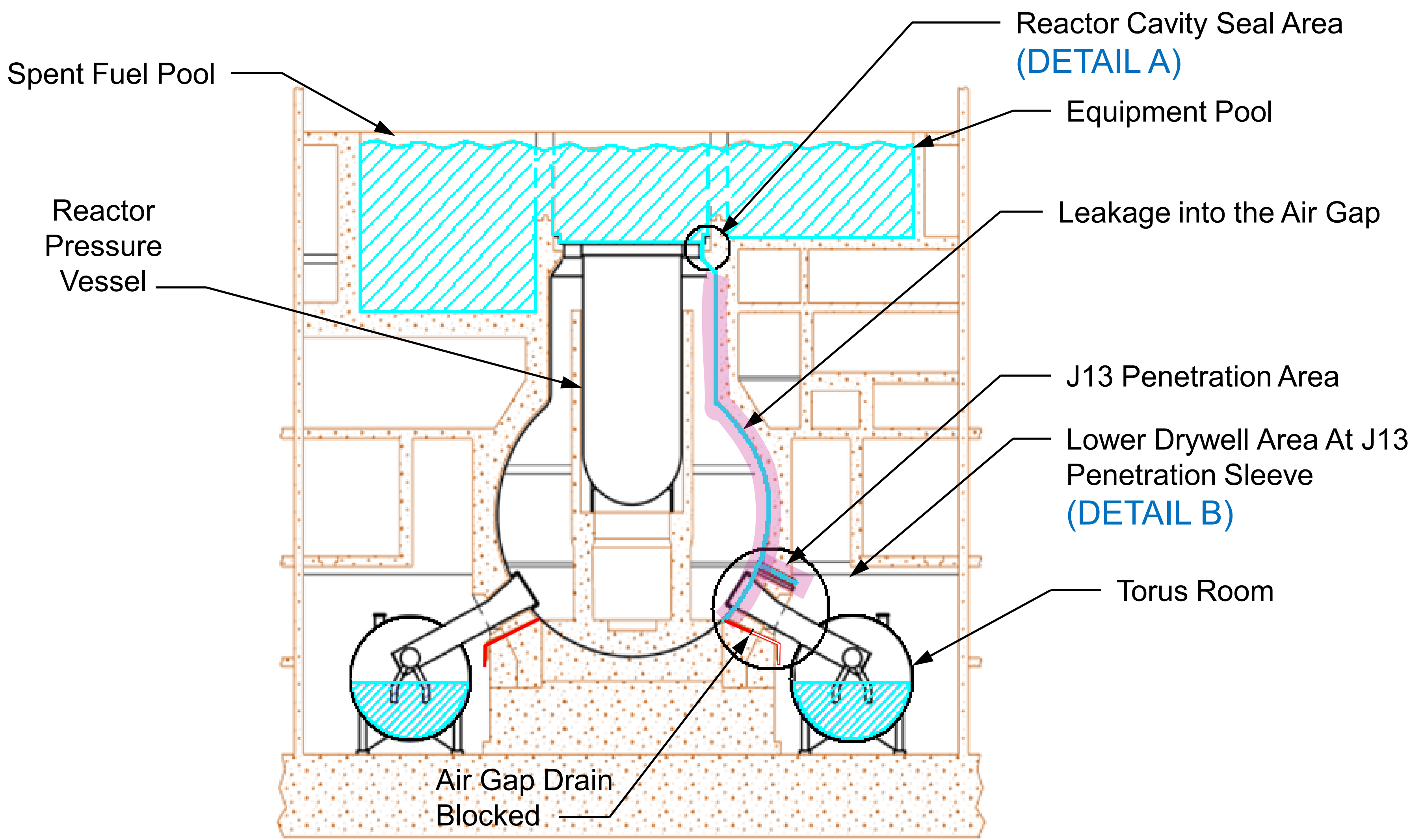
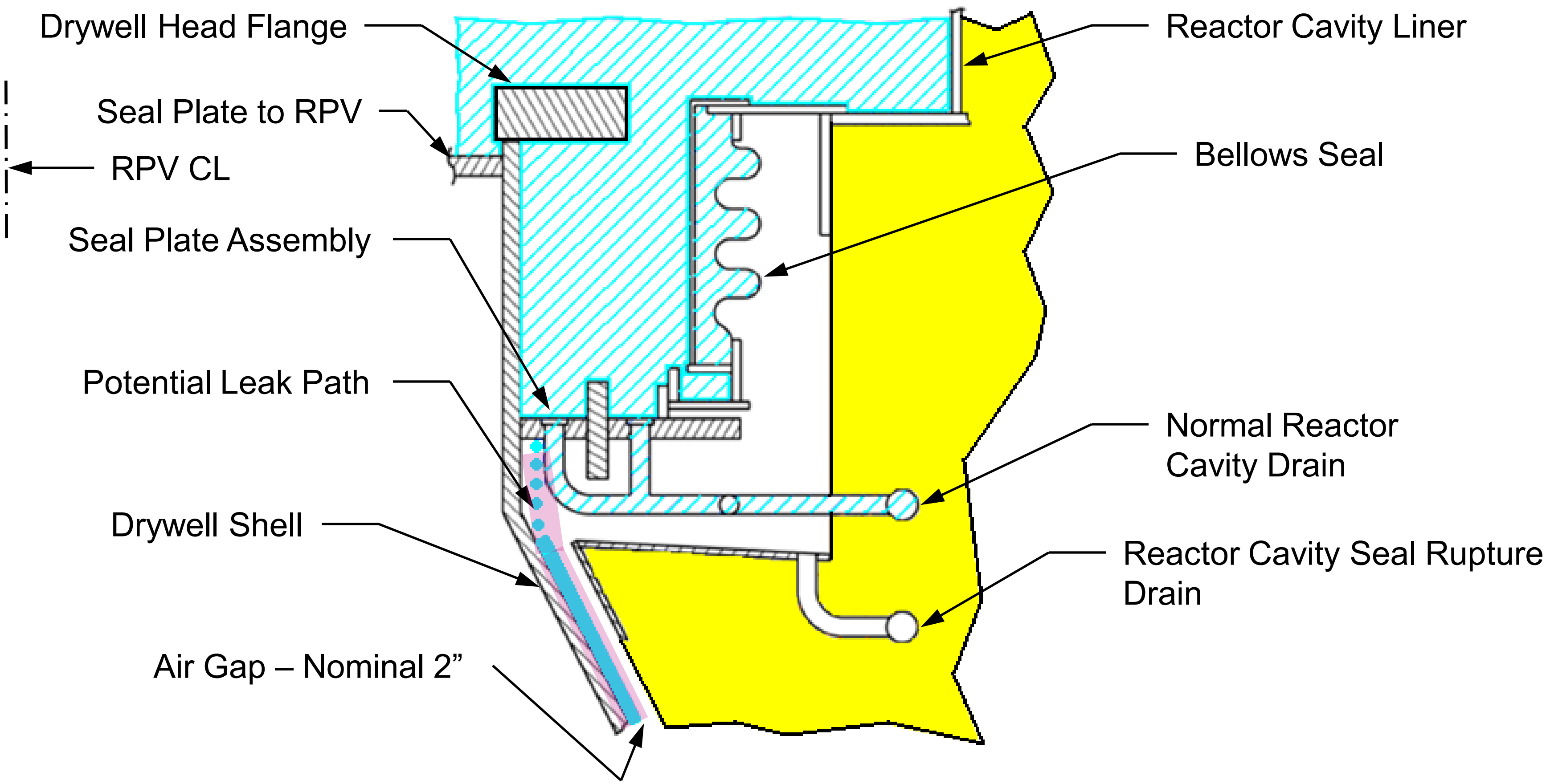
Mark I Containment
During Refueling Operation

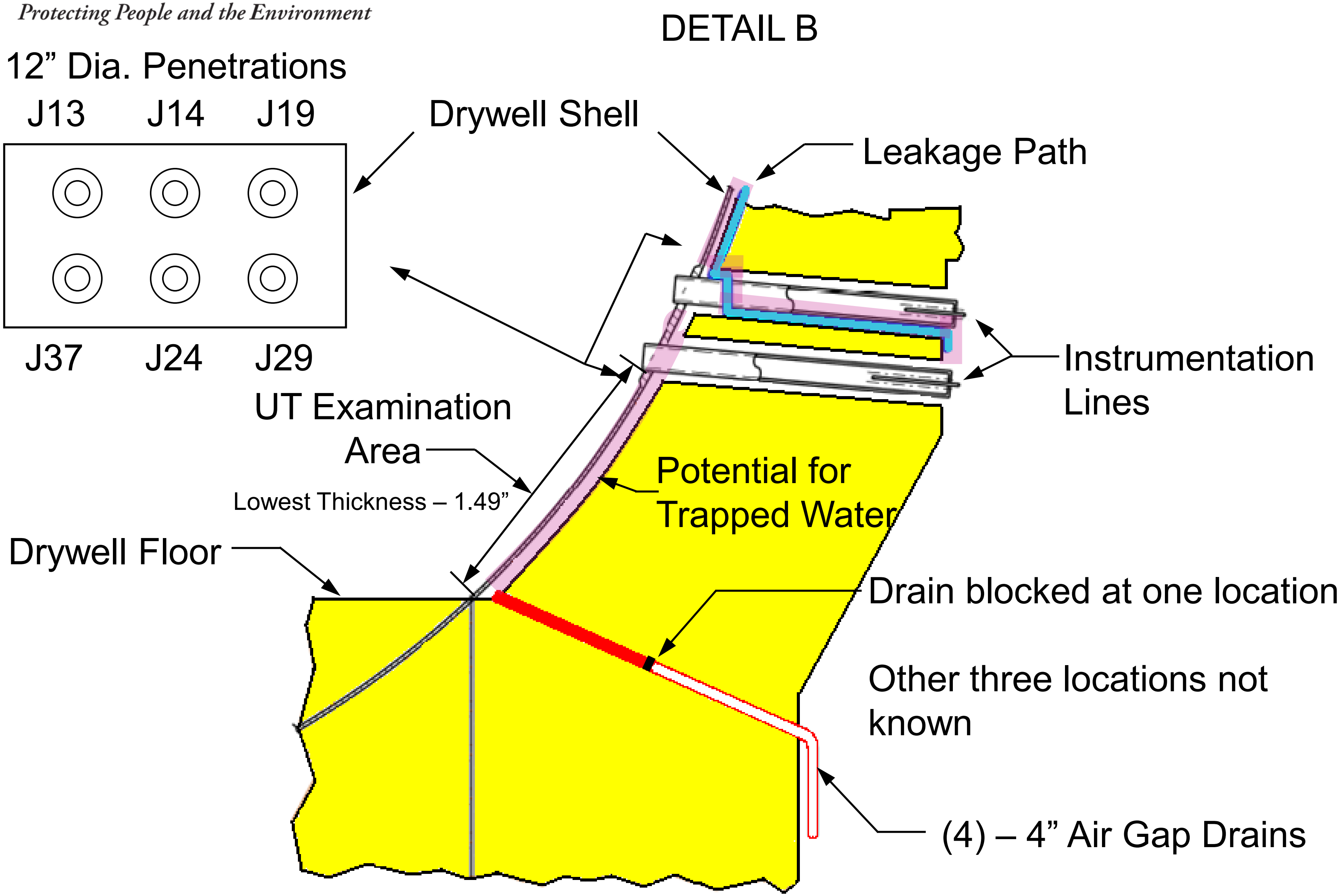


Drywell / Reactor Cavity Seal Area

DETAIL A



Lower Drywell Area



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Options for Proceeding with Future Level 3 Probabilistic Risk Assessment Activities

Dan Hudson, Project Manager
Office of Nuclear Regulatory Research

June 8, 2011

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Agenda

- Introduction
- Background
- Commission Tasking
- NRC Approach and Scoping Study
- Potential Future Uses for Level 3 PRAs
- Options for Proceeding with Future Level 3 PRA Activities
- Staff’s Assessment and Recommendation

Presentation Objectives

- To discuss the staff's approach and options for proceeding with future Level 3 PRA activities.
- To answer questions and obtain feedback from ACRS members on the staff's approach and developed options.
- To obtain ACRS support for the staff's recommendation.

Schedule Overview

February 2010	Commission Meeting
March 2010	Commission Tasking
November 2010	ACRS Subcommittee Meeting
March 2011	Regulatory Information Conference
April 11, 2011	Category 2 Public Meeting
May 11, 2011	ACRS Subcommittee Meeting
May 31, 2011	Task Force Briefing
June 1, 2011	EDO/DEDO Alignment Meeting
June 8, 2011	ACRS Full Committee Meeting
July 7, 2011	SECY Paper Due to Commission
July 28, 2011	Commission Meeting

Overall Vision

To extract ***new and improved*** risk insights to enhance regulatory decision making and to help focus limited agency resources on issues ***most important to public health and safety*** by:

- Incorporating technical advances
- Expanding analysis scope
- Achieving analytical consistency

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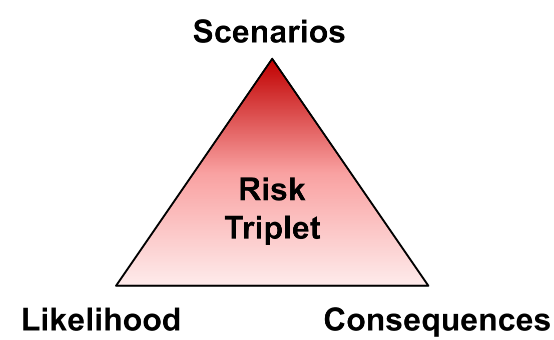
The Value of PRA

A structured, analytical process that provides both ***qualitative insights*** and quantitative estimates of risk by answering three fundamental questions.

1) What can go wrong?
2) How likely is it?
3) What are the consequences?



Scope of Nuclear Power Plant PRAs

Factor	Scoping Options for Commercial Nuclear Power Plant PRAs
Radiological sources	Reactor core(s) Spent nuclear fuel (spent fuel pool and dry cask storage) Other radioactive sources (e.g., fresh fuel and radiological wastes)
Population exposed to hazards	Onsite population Offsite population
Initiating event hazard groups	Internal hazards • Internal events (transients, loss-of-coolant accidents) • Internal floods • Internal fires
	External hazards • Seismic events • Other site-specific external hazards (e.g., high winds, external flooding)
Plant operating states	At-Power Low-Power/Shutdown (LPSD)
End state/Level of risk characterization	Level 1 PRA: Initiating event to <u>onset of core damage</u> or safe state Level 2 PRA: Initiating event to <u>radioactive material release to environment</u> Level 3 PRA: Initiating event to <u>offsite radiological consequences</u>

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Historical Perspective

Prior NRC-sponsored studies estimating risk to the public from severe reactor accidents

- WASH-740 (March 1957)*
- WASH-1400 (October 1975)
- NUREG-1150 (December 1990)
- Present day

18 years

15 years

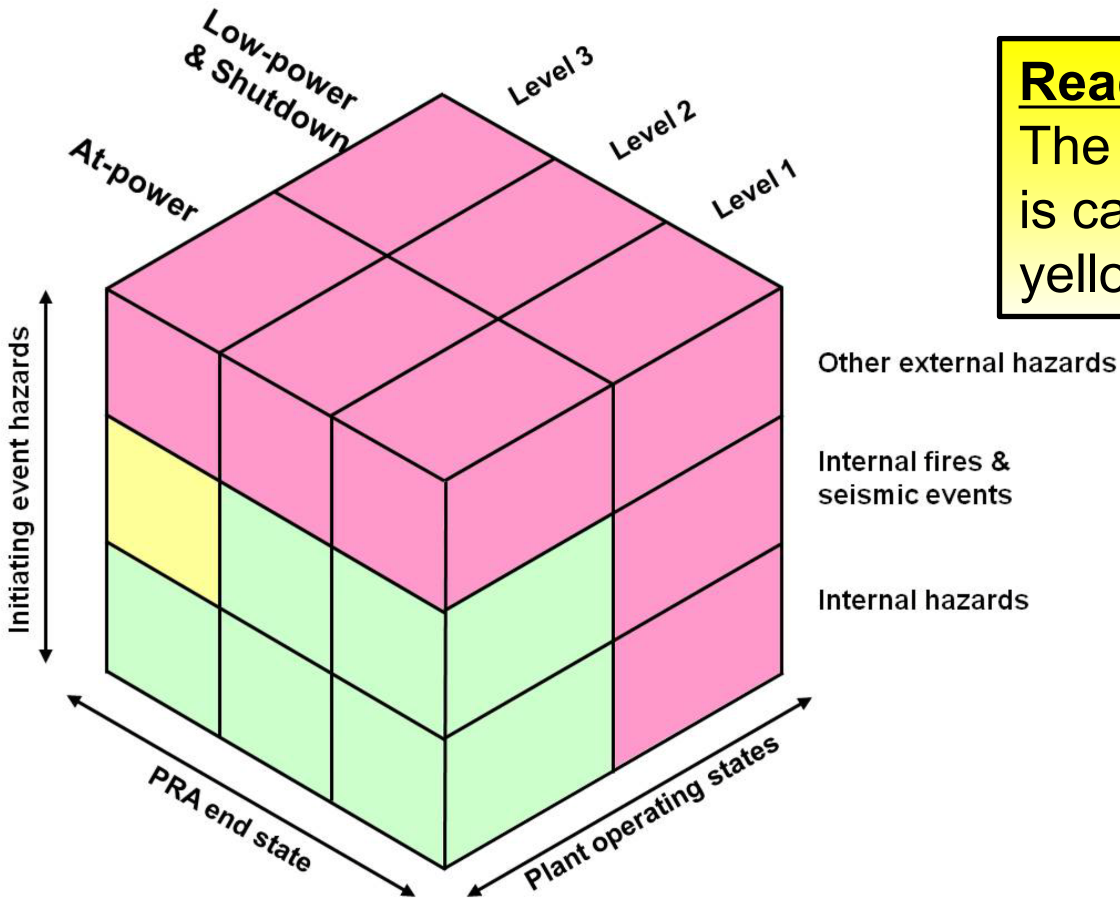
20 years

*** Not a Level 3 PRA study.**

Basis for New Site Level 3 PRA Initiative

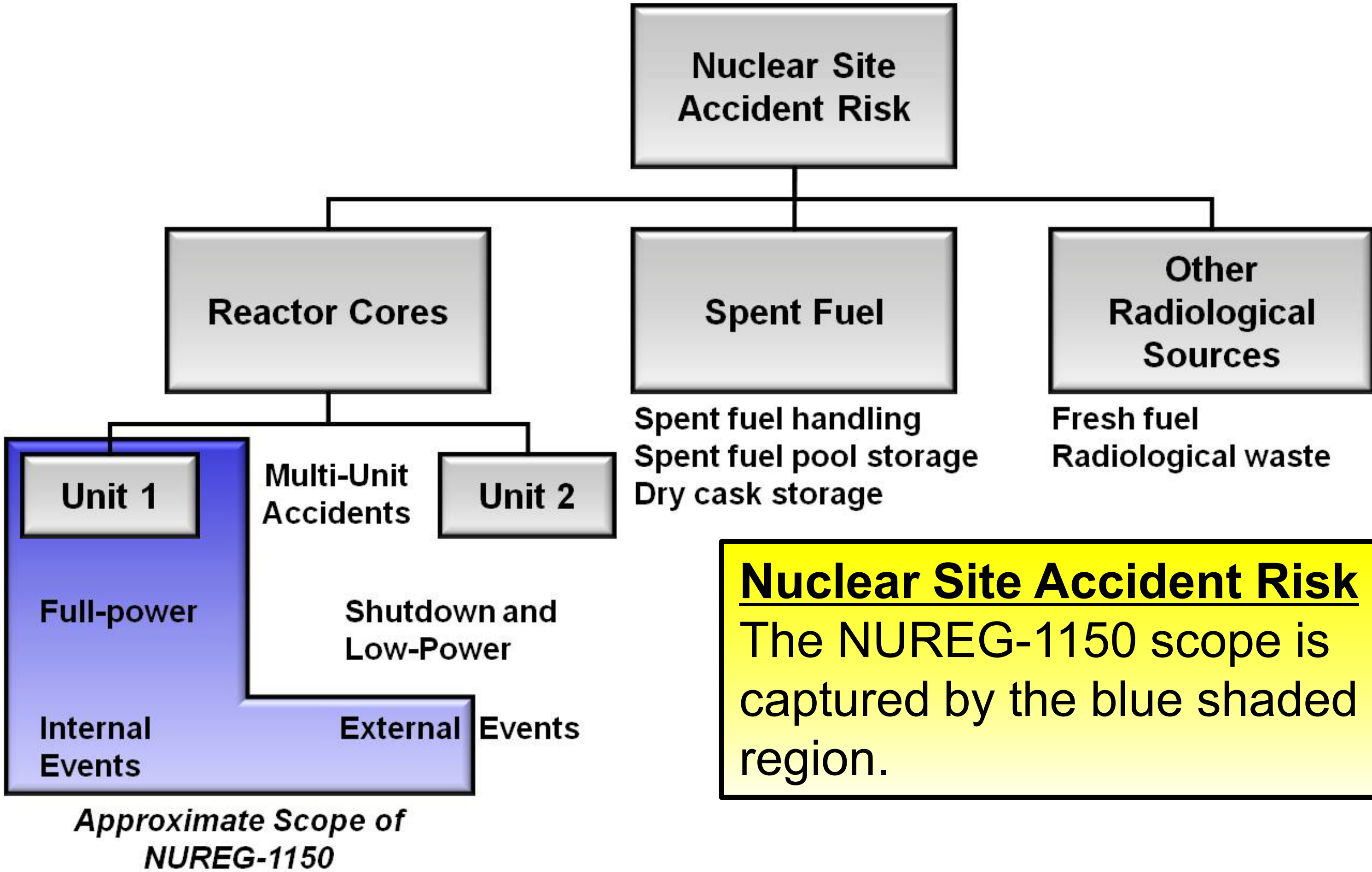
- **Technical advances since NUREG-1150**
  - Modifications to enhance nuclear power plant safety and security
  - Improved understanding and modeling of severe accident phenomenology
  - Advances in PRA technology
- **Additional scope considerations**

Basis for New Site Level 3 PRA Initiative



Reactor Accident Risk
The NUREG-1150 scope is captured by green and yellow shaded regions.

Basis for New Site Level 3 PRA Initiative



<u>Nuclear Site Accident Risk</u>
The NUREG-1150 scope is captured by the blue shaded region.

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Commission Tasking

Staff requirements memorandum M100218

- Continue internal coordination efforts and engage external stakeholders in formulating a plan and scope for future actions.
- Provide the Commission with various options for proceeding which include costs and perspectives on future uses for Level 3 PRAs.

Three-Phased Approach

Phase 1: Scoping Study

Phase 2: Selected Option for Proceeding*

Phase 3: Follow-on Activities*

*** Phases 2 and 3 both require further Commission direction**

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Scoping Study Objectives

- **Identify potential future uses**
- **Develop options for proceeding**
  - Scope of the analysis
  - PRA technology to be used
  - Site selection considerations
  - Resource estimates
- **Determine feasibility**
- **Obtain external stakeholder views**
- **Identify staff's recommendation**

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Scoping Study Activities

- **Internal Coordination Activities**
  - Workshops
  - Coordination and alignment meetings
  - Briefings
- **External Stakeholder Engagement Activities**
  - ACRS interactions
  - Regulatory Information Conference (RIC) presentations
  - Category 2 public meeting

Potential Future Uses for Level 3 PRAs

- Confirm acceptability of NRC's current use of PRA
- Verify/update regulatory requirements and guidance
- Support specific risk-informed regulatory applications
- Develop and pilot test PRA technology, standards, and guidance
- Prioritize generic issues and safety research programs
- Support PRA knowledge management and risk communication activities
- Support future risk-informed licensing of new and advanced reactor designs

Options for Proceeding

<u>Option 1</u>: Maintain Status Quo – Continue Evolutionary Development of PRA Technology

<u>Option 2</u>: Conduct Focused Research to Address Identified Gaps in Existing PRA Technology Before Performing a Full-Scope Comprehensive Site Level 3 PRA

<u>Option 3</u>: Full-Scope Comprehensive Site Level 3 PRA – Operating Nuclear Power Plant

Option 1: Maintain Status Quo

Potential Objectives

- Continue ongoing and planned research to develop and improve upon existing PRA technology on a resource-available basis.

Advantages

- Consistent with current fiscal climate by focusing limited available resources on existing mission-critical work.

Disadvantages

- Insights from a new full-scope comprehensive site Level 3 PRA would not be realized.
- Potentially inconsistent and more costly treatment of future issues by developing the necessary PRA technology on an ad-hoc basis.

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Option 2: Research to Address Gaps

Potential Objectives

- Ensure important technical gaps are closed ***before*** developing a new full-scope comprehensive site Level 3 PRA.

Scope (example research areas)

- Modeling of consequential (linked) multiple initiating events
- Modeling of multi-unit dependencies
- Post-core damage and external events human reliability analysis
- Spent fuel PRA technology
- Level 2 and Level 3 PRA uncertainty analysis

Option 2: Research to Address Gaps

Advantages

- Acknowledges challenges associated with current budget climate while making progress.
- Focuses limited available resources on existing mission-critical work.
- Focuses additional resources already requested on needed research.
- Enhances PRA capability in specific technical areas.
- Enables better understanding of potential resource implications of related efforts before committing.

Disadvantages

- Insights from a full-scope comprehensive site Level 3 PRA would be delayed.
- May result in a duplication of scoping study effort.

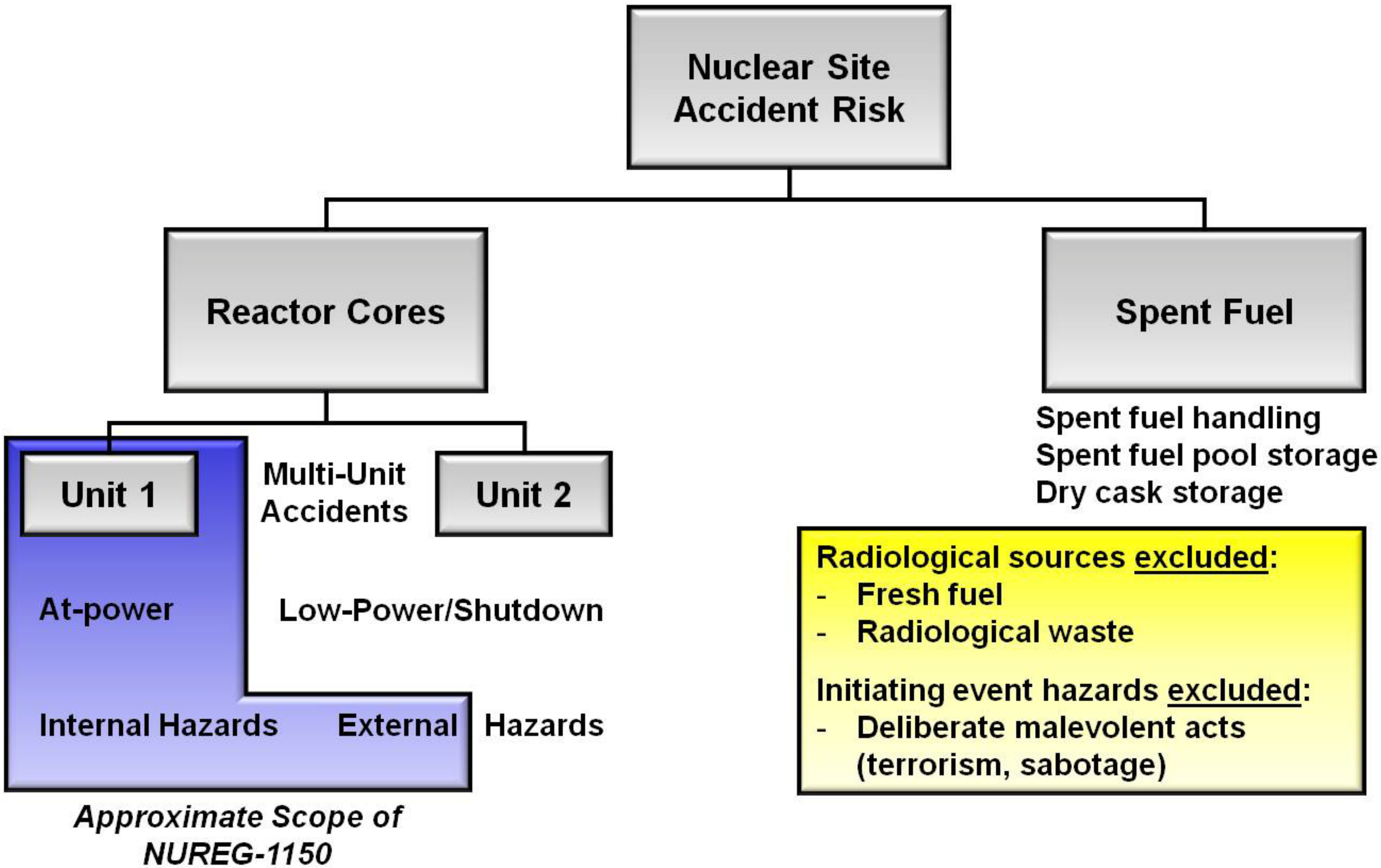
Option 3: Full-Scope Site Level 3 PRA

Potential Objectives

- Extract new and improved risk insights
- Enhance PRA capability, expertise, and documentation
- Demonstrate technical feasibility and evaluate realistic cost

Option 3: Full-Scope Site Level 3 PRA

Proposed Level 3 PRA Scope



Option 3: Full-Scope Site Level 3 PRA

PRA Technology

- Standardized Plant Analysis Risk (SPAR) Models
- Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE), Version 8
- MELCOR Severe Accident Analysis Code
- MELCOR Accident Consequence Code System, Version 2 (MACCS2)

Option 3: Full-Scope Site Level 3 PRA

Site Selection Considerations

- Multi-unit
- SPAR model capability
- Availability of MELCOR input decks
- National Fire Protection Association (NFPA) Standard 805 transition
- Site-specific external hazards
- Spent fuel pool storage configuration
- Independent Spent Fuel Storage Installations (ISFSIs)

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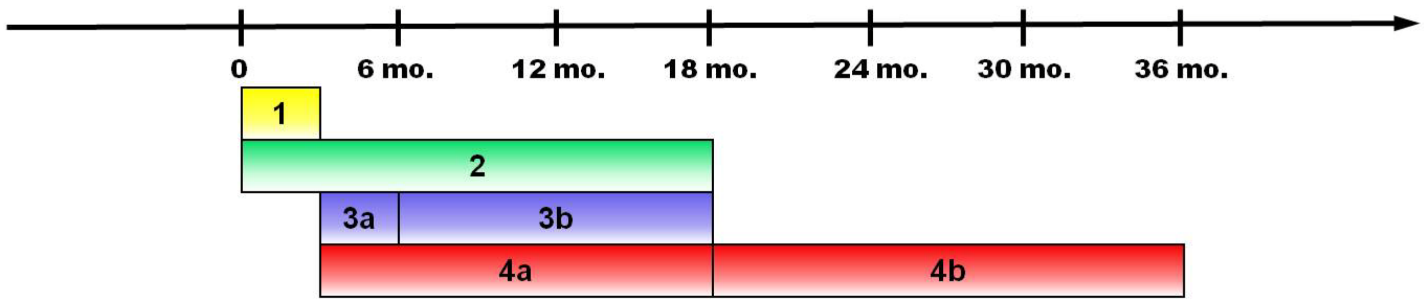
Option 3: Full-Scope Site Level 3 PRA



Phase 1: Getting Started
- Contract placement
- Site selection

Phase 2: Research to Address Gaps
- Consequential multiple initiating events
- Multi-unit modeling
- Post-core damage & external events HRA
- Spent fuel PRA technology
- Level 2/3 PRA uncertainty analysis

Phases 3 and 4:
a – Information collection phase
b – Modeling and analysis phase

Phase 3: Internal Events Level 3 PRA
- Reactor core(s) (at-power, LPSD)
- Spent fuel
  - Storage (SFP, DC)
  - Transport (Rx-SFP, SFP-DC)

Phase 4: External Events Level 3 PRA
- Reactor core(s) (at-power, LPSD)
- Spent fuel

External Events
- Internal floods and fires
- Seismic events
- Site-specific external hazards
  - High winds/tornadoes
  - Hurricanes/tsunamis
  - External flooding

Option 3: Full-Scope Site Level 3 PRA

Advantages

- Provides near-term new and improved risk insights.
- Provides near-term enhanced PRA capability.
- Prevents a duplication of effort.

Disadvantages

- Resource-intensive.

Staff's Assessment

A new and more comprehensive site Level 3 PRA would be beneficial.

Obtaining additional resources to support this initiative is unlikely.

Reallocating resources would be challenging due to:

- Existing mission-critical work assigned to a limited number of risk analysts
- Potential for work related to follow-up actions from the recent event in Japan

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Staff's Recommendation

Option 2: Conduct Focused Research to Address Identified Gaps in Existing PRA Technology Before Performing a Full-Scope Comprehensive Site Level 3 PRA

Contact Information

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Acronyms and Abbreviations

ACRS	Advisory Committee on Reactor Safeguards
DC	dry cask
DEDO	Deputy Executive Director for Operations
DRA	RES Division of Risk Analysis
EDO	Executive Director for Operations
ISFSI	independent spent fuel storage installation
LPSD	low-power/shutdown
MACCS2	MELCOR Accident Consequence Code System, Version 2
NFPA	National Fire Protection Association
NRC	U.S. Nuclear Regulatory Commission
PRA	probabilistic risk assessment
RES	NRC Office of Nuclear Regulatory Research
RIC	Regulatory Information Conference
SAPHIRE	Systems Analysis Programs for Hands-on Integrated Reliability Evaluations
SECY	NRC Office of the Secretary of the Commission
SFP	spent fuel pool
SPAR	standardized plant analysis risk

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Advisory Committee on Reactor Safeguards

Bulletin 2011-01, "Mitigating Strategies"

Eric E. Bowman, Sr. Project Manager, NRR/DPR

June 8, 2011

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Purpose

1. To achieve comprehensive verification of compliance with 10 CFR 50.54(hh)(2)
2. To gather information on licensee programs in order to determine if:
   a. Additional assessment is needed
   b. The current inspection program should be enhanced, or
   c. Further regulatory action is warranted.

Background

- Fukushima Daiichi Fuel Damage Event and the use of ad hoc mitigation highlight the potential significance of the mitigating strategies to non-security-related initiating events

NRC Inspection Efforts

- Comprehensive Phase 1 Inspections 2005 – 2006
- Comprehensive Phase 2 & 3 Inspections 2008
- Integrated into ROP as part of triennial fire protection inspection

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30-Day Request

1. Is the equipment necessary to execute the mitigating strategies, as described in your submittals to the NRC, available and capable of performing its intended function?
2. Are the guidance and strategies implemented capable of being executed considering the current configuration of your facility and current staffing and skill levels of the staff?

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Basis

- Basis for the 30-day request is to verify the current compliance with 10 CFR 50.54(hh)(2)

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60-Day Request, Questions 1 - 3

1. Describe in detail the maintenance of equipment procured to support the strategies and guidance required by 10 CFR 50.54(hh)(2) in order to ensure that it is functional when needed.
2. Describe in detail the testing of equipment procured to support the strategies and guidance required by 10 CFR 50.54(hh)(2) in order to ensure that it will function when needed.
3. Describe in detail the controls for assuring that the equipment is available when needed.

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60-Day Request, Questions 4 and 5

4. Describe in detail how configuration and guidance management is assured so that strategies remain feasible.
5. Describe in detail how you assure availability of off-site support.

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Basis

- Basis for the 60-day request is to verify compliance regarding implementation and maintenance of the strategies

Discussion

- B.5.b guidance contains limited detail on maintenance, training and control of equipment, training requirements, and validation of feasibility of strategies
  – Phase 1 Guidance Document of 2/25/2005
  – NEI 06-12, Revision 2, as endorsed

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Maintenance, Testing and Control of Equipment

"Equipment associated with these strategies will meet standard industry practices for procuring and maintaining commercial equipment."

Training

“Level of training on implementing procedures/guidance is expected to be consistent with SAMG-type actions….”

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Off-site Support

- B.5.b Phase 1 effort included verification and evaluation of memoranda of understanding, etc.

Use of Information Obtained

- The 60-Day responses will be analyzed to determine if there is an adequately defined standard in use by the industry for these items.
- Information obtained will be included in the evaluation of the need for further regulatory action.

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Interaction with NTTF Efforts

- Bulletin 2011-01 is an independent NRR task to verify 50.54(hh)(2) compliance.
- Should any NTTF recommendations involve the subject matter for Bulletin 2011-01, NRR's intent is to evaluate the interaction and ensure that the resulting efforts are aligned and unified as appropriate.

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Inter-Office Coordination

- NRR Current Guidance on 50.54(hh)(2):
  - Phase I Guidance Document of February 25, 2005
  - NEI 06-12, Revision 2, as endorsed
- NRO Current Guidance on 50.54(hh)(2):
  - NEI 06-12, Revision 3, as endorsed
  - DC/COL-ISG-016 of June 9, 2010
- Any regulatory action will be coordinated with NRO to ensure technical consistency

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Questions?