Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title:	Advisory Committee on Reactor Safeguards Open Session
Docket Number:	(n/a)
Location:	Rockville, Maryland
Date:	Wednesday, November 6, 2019
Work Order No.:	NRC-0679 Pages 1-89

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1323 Rhode Island Avenue, N.W.
Washington, D.C. 20005
(202) 234-4433

DISCLAIMER

UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Reactor Safeguards, as reported herein, is a record of the discussions recorded at the meeting.

This transcript has not been reviewed, corrected, and edited, and it may contain inaccuracies.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

668TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

+ + + + +

OPEN SESSION

+ + + + +

WEDNESDAY

NOVEMBER 6, 2019

+ + + + +

ROCKVILLE, MARYLAND

+ + + + +

The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B10, 11545 Rockville Pike, at 1:00 p.m., Peter Riccardella, Chairman, presiding.

COMMITTEE MEMBERS:

PETER RICCARDELLA, Chairman
MATTHEW W. SUNSERI, Vice Chairman
JOY L. REMPE, Member-at-Large
RONALD G. BALLINGER, Member
DENNIS BLEY, Member
CHARLES H. BROWN, JR. Member
VESNA B. DIMITRIJEVIC, Member
WALTER L. KIRCHNER, Member
JOSE MARCH-LEUBA, Member
DAVID PETTI, Member

DESIGNATED FEDERAL OFFICIAL:

CHRISTOPHER BROWN

ALSO PRESENT:

MIKE BLOOM, Duke Energy
JOSH BORROMEO, NRR
MARK DeWIRE, Duke Energy
STEVE EVANS, Duke Energy
TIM HARDIN, EPRI
ALLEN HISER, NRR
ANDY HON, NRR
RAJ IYENGAR, RES
MEENA KHANNA, NRR

ALSO PRESENT (CONTINUED):

JOHN LEHNING, NRR
LOUISE LUND, RES
SCOTT MOORE, Executive Director, ACRS
JEFF POEHLER, RES
DOUG PRUITT, Framatome
MARY JANE ROSS-LEE, NRR
DAVID RUDLAND, NRR
ASHLEY SMITH, NRR
DAN TINKLER, Framatome
ROBERT TREGONING, RES
DAN WIDREVITZ, NRR
AARON WYSOCKI, ORNL
PETER YARSKY, RES*
STEPHEN YODERSMITH, Duke Energy

*Present via telephone

CONTENTS

Call to Order and Opening Remarks 5
White Paper Addressing Adequacy of RG 1.99, "Radiation Embrittlement of Reactor Vessel Materials," Revision 2, and Working Group Efforts 7
Opportunity for Public Comment 68
Committee Discussion 69
Brunswick Atrium 11 Fuel Transition and Application/Framatome 77
Opportunity for Public Comment 89
Adjourn 89

P R O C E E D I N G S

1:03 p.m.

CHAIRMAN RICCARDELLA: (presiding) The meeting will come to order.

This is the first day of the 668th meeting of the Advisory Committee on Reactor Safeguards. I'm Pete Riccardella, Chairman of the Committee.

ACRS was established by the Atomic Energy Act and is governed by the Federal Advisory Committee Act, or FACA. The ACRS section of the U.S. NRC public website provides information about the history of the ACRS and provides FACA-related documents, such as our Charter, Bylaws, Federal Register notices for meetings, letter reports, and transcripts of full and subcommittee meetings, including slides presented at the meetings. The Committee provides advice on safety matters to the Commission through its publicly-available letter reports.

The Federal Register notice announcing the meeting was published on October 16th, 2019, and provides an agenda and instructions for interested parties to provide written documents or request

opportunities to address the Committee, as required by FACA.

In accordance with FACA, there is a Designated Federal Official, or DFO, for today's meeting. The DFO for this meeting is Mr. Christopher Brown.

During today's meeting, the Committee will consider the following: the White Paper addressing the adequacy of Regulatory Guide 1.99, "Radiation Embrittlement of Reactor Vessel Materials," Rev 2, and, two, Brunswick Atrium 11 fuel transition and application. And three, preparation for our December meeting with the Commission. And then, also, if we have time today, preparation of reports, which I doubt we'll get to.

There's a phone bridge line. To preclude interruption of the meeting, the phone will be kept in listen-only mode during the presentations and Committee discussions.

We have received no written comments or requests to make statements from members of the public regarding today's meeting. There will be an opportunity for public comments, as we have set aside 10 minutes in the agenda for comments from members of the public attending or listening to our meetings.

Written comments may be forwarded to Mr. Christopher Brown, the DFO.

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

And I would also request that everybody turn off or silence their cell phones to avoid interruption of the meeting.

With that, I will turn the meeting over to Louise Lund, who will introduce the first topic.

MS. LUND: Yes. Thank you. And thanks to the Committee for having us here today.

My name is Louise Lund. I'm the Division Director for the Division of Engineering in the Office of Research.

And today, we're here to talk about Regulatory Guide 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials," which is used by licensees in the operating fleet to determine the change in reactor vessel properties due to radiation.

So, the guidance in the Reg Guide is used to determine the adjusted reference temperature, which

is used to determine the fracture toughness, a key input to pressure-temperature limits. The Reg Guide also provides guidance for assessing the change in upper shelf energy, which is related to ductile fracture resistance. And both of these properties are needed to show compliance with 10 CFR 50, Appendix G.

And I think that it's been noted that the current Reg Guide dates from 1988. Since that time, there has been a large amount of test data on irradiated reactor vessel materials which have been obtained from test or surveillance materials. So, with licensees planning to operate plants out to 60 or 80 years, it is important that guidance for assessing embrittlement be adequate for the neutron fluence levels that are projected for those plants. New plants will use reactor vessel materials with different chemistries than the operating fleet.

Therefore, the staff performed an assessment of the adequacy of Reg Guide 1.99, Rev 2, based on these considerations. And the presentation today summarizes the multiyear effort to assess Reg Guide 1.99 through a modern data-driven approach.

And based on a lot of the discussions we had at the Subcommittee, we also have discussed in the presentation the next steps that we have been

formulating for the staff based on this assessment, including the formulation and activities of a working group for this purpose and an oversight group to develop revision of Reg Guide 1.99.

So, without further ado, I'm going to go ahead and turn it over to the staff. You have Allen Hiser and Dan Widrevitz and Jeff Poehler in front of you today.

MR. POEHLER: Good afternoon.

I'm going to introduce the presentation today. So, this is Regulatory Guide 1.99, Revision 2, assessment results and follow-on activities. This presentation summarizes a multiyear effort to thoroughly assess Reg Guide 1.99 through a modern data-driven approach; plus, the activities underway to address the assessment results.

And here's an outline of today's presentation. First, we're going to go through some background on the current Regulatory Guide 1.99. Then, we're going to talk about the assessment results, which cover RTndt; upper shelf energy; credibility criteria; plant-specific data results; attenuation results; common additions to the Reg Guide that are not actually in the Reg Guide, but these are basically common practices; conclusions. We will,

then, discuss the Reg Guide 1.99 working group charter and activities. And then, we'll discuss the Reg Guide 1.99 oversight group charter and activities.

MEMBER KIRCHNER: Jeff, so you don't get a crook in your neck, why don't you borrow Dan's microphone? That one seems to work better.

MR. POEHLER: How's that? Is that better?

MEMBER KIRCHNER: Much better.

MEMBER BLEY: Much better.

MR. POEHLER: Okay. Great.

So now, I'm going to turn it over to Dan to cover the results of the assessment.

(Laughter.)

MR. WIDREVITZ: Good afternoon, everyone. My name is Dan Widrevitz, and I have a working microphone.

(Laughter.)

And I'm also the lead author of this report. Obviously, it's the product of a number of employees, current and former, all of whom who are currently in this room.

And so, just to give a little bit of background -- I know many of you were here for the Subcommittee meeting, but I know several of you weren't -- the Regulatory Guide 1.99 provides guidance

with regards to radiation embrittlement of reactor vessel materials. As we will repeat ad nauseam, it was issued in May of 1988.

MEMBER BALLINGER: Which is, by the way, probably before you were born.

MR. WIDREVITZ: Not quite. I remember Ghostbusters.

(Laughter.)

The curve itself, it contains a number of aspects, one of which is an embrittlement trend curve purporting to predict the shift in ductile-to-brittle transition temperature of reactor vessel steels, which we call RTndt. This curve was fit to what was done 177 data points, datums. There was a relative paucity of data at higher fluences because the fleet was relatively young. And there was a relative paucity of data concerning low copper materials because the fleet designs were relatively old.

The Regulatory Guide also includes trend curve for upper shelf energy, which is a measure of toughness of a material once you've entered the ductile regime, which is used in concordance with an acceptance criteria in 10 CFR 50, Appendix G. I'll discuss what we do with RTndt in the next slide.

It contains what we call the credibility

criteria, which are a set of criteria for plant-specific surveillance data that allow a certain manipulation of the embrittlement trends curves if you have good data, like the credibility criteria determined to be good data.

And finally, it has an attenuation formula based on dpa studies which allows you to predict the change in embrittlement as you go through the steel of the vessel and, essentially, as your neutron flux attenuates, you'll receive less damage as you go through. And this is a way of estimating where you are at different depths within the vessel.

So, what do we do with RTndt? We calculate something called adjusted reference temperature, which is you take your estimate of unirradiated RTndt, you add a delta RTndt, which is essentially from the curve in the Reg Guide, and you get a margin where the margin's trying to capture your uncertainties in measurement in the database, et cetera.

The ART is used to determine fracture toughness when developing pressure-temperature limits for operating the plant. And the entire Reg Guide's approach is contained with 10 CFR 50.61, which uses the same model as Reg Guide 1.99.

So, in terms of results, RTndt results, our analysis was conducted using what we call the baseline dataset, which was generated by ASTM E10.02, which is available on the ASTM website. The dataset includes domestic and international power reactor data. Something like half of it is domestic. It's a total of 1900 data points. It's a much, much larger database than was available in the '80s.

And we performed a number of in-depth statistical analyses. I won't get into these. There is a lot of information in the assessment report itself.

In terms of interesting results, what we have plotted here are two plots of the residuals. That's essentially your prediction minus measured values. The top plot is for what we call base materials, plates and forgings, et cetera. The red dots are U.S. data. The gray dots are international data.

And if you look way at the high end -- the X-axis is fluence -- you see that the measured values begin to significantly outweigh the predicted values, so larger. So, that's a non-conservative prediction of embrittlement results that we're seeing for measured data comparing to prediction. So, that's a

bit concerning since PWRs are all heading in that direction in terms of fluence.

CHAIRMAN RICCARDELLA: Just for the record, negative values on that are non-conservative.

MR. WIDREVITZ: Yes, negative values mean that the measure is larger than the predicted.

CHAIRMAN RICCARDELLA: Right.

MR. WIDREVITZ: Which is non-conservative for our use.

Now the similar plot for weld materials does not clearly show this trend. And whether that's an artifact of the paucity of data at high fluence or whether it's an artifact of how the curves were originally put together -- if we want, there's a paper by Randall that discusses how the Reg Guide 1.99 curves are put together, if you want more detail.

There doesn't appear to be the same effect for welds. And traditionally, welds have been some of our more concerning materials in terms of how we generate our safety approach.

So, a lot of interesting questions. This is really the top result. So, to sum it up, our --

CHAIRMAN RICCARDELLA: Also just for clarity, the horizontal dashed lines on that, they're two sigma lines, but not of this data. They're two

sigma lines that are in the Reg Guide that we use to determine the margin, right?

MR. WIDREVITZ: Yes, those are the Reg Guide standard deviations, which I will say in a few minutes are wrong.

CHAIRMAN RICCARDELLA: Well --

MR. WIDREVITZ: Well, they're off.

CHAIRMAN RICCARDELLA: They're wrong, yeah --

MR. WIDREVITZ: Compared to the modern dataset.

CHAIRMAN RICCARDELLA: Yes.

MR. WIDREVITZ: I mean, you're always limited by your dataset.

CHAIRMAN RICCARDELLA: But, again, if you look at the weld, the lower horizontal dashed line on the weld plot, you only have a couple of data points that actually are outside of that main --

MR. WIDREVITZ: And if you look at the print version, which is less saturated than these TVs, what you'll see in welds is there's quite a bit of number of points above the dotted line for welds --

CHAIRMAN RICCARDELLA: Yes.

MR. WIDREVITZ: -- which is an overly-conservative estimate.

CHAIRMAN RICCARDELLA: Yes.

MR. WIDREVITZ: Which, from a safety perspective --

CHAIRMAN RICCARDELLA: Yes.

MR. WIDREVITZ: -- is not an issue.

CHAIRMAN RICCARDELLA: Uh-hum. Okay. Thank you.

MR. WIDREVITZ: So, in terms of results, our primary conclusions: non-conservative high fluence results for base metals become prominent at fluences above, we generally say 6 times 10 to the 19th neutrons per centimeter squared. And that's where your mean of your results goes below 2 sigma, the Reg Guide's 2 sigma. So, you would expect your results, on average, to be too low there.

And also, you get inaccurate low copper results because the Reg Guide simply wasn't fed with low copper data. The interpolation just didn't capture those behaviors.

In terms of secondary conclusions, the standard deviation of delta RTndt in the Reg Guide seems too low when compared to a modern database. There's a conservative bias in low to mid fluences, which some mind consider a burdensome estimate. And there's a lack of temperature adjustment, which is an

accuracy issue. For the current fleet, how big that accuracy issue is is something you can discuss. But when you think about applicants like NuScale who are off the chart in terms of temperature, that becomes more of a deficiency if you wanted to apply the Reg Guide to that.

In terms of delta used results, the assessment for delta used was based on the REAP dataset, which is a collection of surveillance, plant surveillance results merged with the actual material properties in baseline. The dataset, again, included domestic and international power reactor data, 1200 data points, considerably more than we had in the '80s.

What you see here is a plot attempting to show the significance of the results. So, the question in upper shelf energy is, Appendix G has an energy criteria, 50 foot-pounds. And when you go below that criteria, you have to conduct what's called an equivalent margins analysis, which is a more sophisticated analysis in terms of your survivability with transients. No plant has failed to succeed one of these. They've gone considerably above 50 foot-pounds.

However, the concern is, if you have a

material where there should be an equivalent margins analysis, and yet you have a prediction that does not indicate that you need to have done one, are you in a difficult spot? So, when we conducted the analysis, on this plot, plants where an equivalent margin analysis should have been triggered, but is not currently predicted, is the lower righthand quadrant. And as you can see, it's just barely anything is in there. It's a statistically insignificant number of our materials, to the best of our knowledge, are in that state. And so, our concern there simply isn't to the same order of magnitude as for RTndt.

So, sort of a conclusion: what we see with the modern datasets is something like 19 percent of the materials measured delta used is not bounded by the Reg Guide model. The Reg Guide was originally drawn as an upper-bound model. So, this is not good behavior for its original intent. There's a very limited number of materials that are currently misprojected or remain above 50 foot-pounds and do not trigger the PNAs.

However, there's a minimal impact. The safety criteria that's supported by upper shelf estimation is known to be extremely conservative. And so, consequently, that's not really an area of further

focus.

In terms of credibility criteria, the Reg Guide has five credibility criteria. You apply these credibility criteria to measured data, which you, then, quote, "refit" in the Reg Guide, where you take what they call a chemistry factor, which is a linear multiplier on your fluence function, and you least squares fit it to your actual data. So, if you've got credible data, you allow a shift of the curve into your data, and then, it allows you to reduce your margin term by a certain amount. If your data is not deemed credible through these five criteria, you do not consider it. You're indicated not to consider it. And this criteria typically has failed because of excessive scatter in your data. A lot of this is fed by Sharpie testing, and Sharpies have a fair amount of scatter. The assessment goes into a great deal of detail on this.

In terms of issues, there's a lot of issues of construction of the credibility criteria. One of them is, the more surveillance data points you have, the more likely it is for data to be deemed non-credible due to scatter. It's not well insulated to have an outlier test that scales with the number of samples you're taking. It has no apparent basis for

the reduction in margin for credible data.

A real critical consequence is that the benefit of fitting predictions to surveillance data is nullified in many cases by the credibility criteria rejecting data that do not perform to the fluence shape function of Reg Guide 1.99. So, when you try to fit a curve to something that just doesn't have the same slope characteristics, you're going to have more rejections. And that's what it does.

Why we're concerned about that here is high fluence and low copper data are not expected to conform to the fluence shape function of Reg Guide 1.99.

MEMBER PETTI: So, in essence, you're potentially throwing out the data?

MR. WIDREVITZ: You are going to throw out data that doesn't look as you expect it. So, that's exactly right.

MEMBER PETTI: And data specific for your plant material.

MR. WIDREVITZ: If your actual material doesn't match the Reg Guide, you're told not to use it. So, it's not --

MR. HISER: Except in one scenario. If your data indicates a higher trend, you don't get to

reduce the margin, but you do get to use the higher chemistry factor.

MR. WIDREVITZ: No.

(Laughter.)

No, you don't enter the procedure if your data is not credible. Common practice has superseded the Reg Guide text. And that gets to something I'll discuss after attenuation.

Sorry. Sorry, Jeff. Go back.

The attenuation formula given in the Reg Guide was based on dpa for studies. All modern data confirmed that it's a fairly good representation of essentially the reduction damage as you go through the steel. The formula only works for areas horizontally adjacent to the active fuel area.

So, what we see now that we have these plants that have been operating for a considerable long time is that our area of interest grows. We essentially say you must look at the area that has fluence 10 to the 17th or greater neutrons per centimeter squared. As your plant ages, that creeps up, and it creeps down on both ends of the active fuel. In areas that are not exactly adjacent to the fuel, you get geometry effects, get a lot of things going on where this formula just doesn't apply.

And so, we actually have a research project on determining fluence outside the beltline in operation. This is to be incorporated in revision of Reg Guide 1.190. Certainly the materials folks here, we're certainly aware, and we keep in touch, but we don't review that directly. So, I'm not going to say anything more about that.

So, common additions. There are several practices not addressed in the Reg Guide that have been commonly accepted by the NRC. In short, a great number of users had difficulties, had questions. The credibility criteria are not particularly tightly-written. And as a result, the NRC had a presentation in 1998 which we tend to call the Wichman presentation where we discussed how to deal with a number of issues that our applicants were encountering.

One of them was the use of sister plant data to supplement plant-specific surveillance data. In this case, this is material that's a heat-for-heat match which has been irradiated in another plant. There, you adjust it by temperature. There's also quite a bit of discussion of what to do with outliers, particularly low fluence outliers, in that presentation. And there are a lot of sort of art-of-practice tips that are critical to successfully using

the Reg Guide that are not entirely consistent with how the Reg Guide is written, depending on how you read it. So, again, the Reg Guide is not very tightly-drawn. A lot of it text. And that's where I think Allen and I, as you just saw, there are some textual ambiguities that certainly this presentation aimed to address.

So, in conclusion, correcting the non-conservatism of the embrittlement trend from higher fluences is the most significant recommendation of the assessment. The credibility criteria should also be revised to make more effective use of plant-specific surveillance data, particularly in those cases where you're failing the credibility criteria because your data is showing genuine trends that do not match the shape function of the Reg Guide. The Reg Guide really only has one shape function, which is sort of on the higher kappa range.

And there are several common practices not addressed in the Reg Guide that should be addressed in a revision, such as the use of sister plant data, implementation of credibility criteria to agree with things that are in the presentation, or otherwise necessary to discuss clarification. This is more deficiency of omission.

I should note that, depending on what one would like to do with the Reg Guide, some of these things would be simply dealt with inherently in a solution. For example, if you replace the trend curve with something that has a temperature term, you no longer need to even consider this degree of the correction in the Wichman presentation.

MR. POEHLER: Okay. Now I'm going to discuss what the staff is doing in response to the issues that were identified in the Technical Letter Report. So, in response to the Technical Letter Report, the NRC has initiated an effort to revise Reg Guide 1.99, and we have chartered two groups for this effort. The first one is a working group, and the second one is an oversight group. And I'm going to talk on the next slide about the working group and what it's doing.

So, the working group's primary task is to develop a revision to Reg Guide 1.99, Rev 2, that will address the recommendations of the TLR. And we're going to give priority to those recommendations with the most significant potential reduction in safety margin, particularly in the non-conservatism in high fluence being the highest priority.

The upper shelf energy model in the

Regulatory Guide will not be addressed because, potentially, non-conservative upper shelf energy predictions have no credible impact on safety, as has been demonstrated by NRC accepted equivalent margin analyses.

The working group is going to concentrate on the technical content of the Regulatory Guide rather than regulatory or implementation issues. And the working group consists of both NRR and Office of Research staff. And Office of Research staff serves as the lead for the working group.

So now, I'm going to talk about some of the tasks or the major tasks that the working group has underway. The first one of those was to recommend an alternate embrittlement trend curve, and that one we have completed. We have selected the ASTM E900-15 embrittlement trend curve as the basis for the revision of Reg Guide 1.99, Revision 2.

Yes?

CHAIRMAN RICCARDELLA: Excuse me, Jeff.

MR. POEHLER: Sure.

CHAIRMAN RICCARDELLA: Does that curve have any sort of temperature adjustment in it?

MR. POEHLER: It has. Temperature is a variable.

CHAIRMAN RICCARDELLA: It's a parameter in it?

MR. POEHLER: Yes.

CHAIRMAN RICCARDELLA: Great. Okay.

MR. POEHLER: The next major task is to determine the limitations -- and these aren't in any particular order, by the way; the next four of these are things that we're working in parallel -- determining the limitations of the embrittlement trend curve implementation. So, these would be limitations on the ranges of the variables. Like all the chemical composition variables, of which there are four, temperature, fluence -- and these would be defined, basically, from the database from which E900 was developed areas of the database. Areas of the ranges of the variables where the data gets thin is going to help us determine what the limitations are.

The next major task is determining how to apply surveillance data. You know, it's just going to be a bit different, how we would do it with the E900 as opposed to how we do it now, just by the nature of the differences in the two different trend curves.

The next --

CHAIRMAN RICCARDELLA: Is this referring to the credibility criteria, this one?

MR. POEHLER: Yes. Yes, in part, yes. And whether you could refit the curve to actual data or not and things like that. Yes.

Reg Guide 1.99 was relatively simply to refit because of the smaller number of variables.

MEMBER KIRCHNER: Jeff, is there any requirement there? If you start refitting the E900 curve, it almost begs the question of why don't you just use the surveillance data that's prototypical for the plant in question. Or at least it leads me to think that, rather than fall back on a curve that's populated by lots of plants with lots of potential variations in material and forging or manufacturing, et cetera.

MR. POEHLER: Yes, I mean, that's a good point, but I think the philosophy is we would rather use the trend curve based on a large amount of data if --

MEMBER KIRCHNER: No, I understand that, right.

MR. POEHLER: -- if your actual plant data is fitting that with respect --

MEMBER KIRCHNER: Yes. Well, it would beg the question of how much data do you have, surveillance data that you could construct your own

curve without having a large uncertainty band, yes.

MR. HISER: Yes, I think one of the things that we would be after is looking at the trend from E900 as a function of fluence because the data can have quite a bit of scatter.

MEMBER KIRCHNER: Yes, yes.

MR. HISER: So, it may indicate that it's well above or well below the E900 prediction.

MEMBER KIRCHNER: Right.

MR. HISER: But we want to be able to maintain some coherency, so that you can calculate a projected embrittlement for the vessel.

MR. WIDREVITZ: Just to clarify, I mean, this is exactly the question that we're working very hard to consider. The question is, when do you gain more from your plant-specific data in terms of handling the uncertainties --

MEMBER KIRCHNER: Exactly. And how many data points do you need?

MR. WIDREVITZ: Right. Because of you're in the middle of your data cloud and you've got a very dense amount of data in your trend curve, then you have a statistical quality there that your plant-specific data can never achieve. There just aren't enough samples. And that's exactly what we're

thinking about.

CHAIRMAN RICCARDELLA: Yes, I mean, how many data points do you typically have after, say, you've pulled three or four surveillance capsules at a plant? What are we talking about?

MR. WIDREVITZ: For material, three or four.

CHAIRMAN RICCARDELLA: Three or four points per material?

MR. WIDREVITZ: Yes.

CHAIRMAN RICCARDELLA: So, that's why.

MR. WIDREVITZ: You're spending a lot of your samples to get that, to find your transition, but now you've only got one measurement of transition out of so many samples.

CHAIRMAN RICCARDELLA: Right.

MR. WIDREVITZ: And that's sort of the data science challenge.

CHAIRMAN RICCARDELLA: Aspect of it. Okay.

MR. POEHLER: Another task would be to determine the margins on the embrittlement trend curve. So, the E900 standard provides an equation for the standard deviation of the prediction. But we would want to structure it more like the current Reg

Guide most likely, which has, you know, it's based on 2 standard deviations, but there's also a standard deviation associated with the initial unirradiated RTndt. So, we would probably keep the same structure, but use the standard deviation of the shift, which is obviously different, for that.

CHAIRMAN RICCARDELLA: Is there a way to risk-inform that as to what the margin should be?

MR. HISER: I think that's probably one of the things we're going to look at. I mean, we don't have at this point preconceived notions of here's what we're going to do.

CHAIRMAN RICCARDELLA: Yes, yes.

MR. HISER: It's more open-ended.

MR. WIDREVITZ: Yes, absolutely. I mean, that's one of the questions we're asking ourselves.

CHAIRMAN RICCARDELLA: It seems to me, I mean, heat-up/cool-down curves really aren't a high-risk part of plant operation, I don't think, are they in terms of creating a --

MR. HISER: It all depends. They're one part of the operation that you use every cycle. So, from that perspective, it's a known transient, if you will.

CHAIRMAN RICCARDELLA: I know, but you

assume a Goretti flow. You put safety factors on the loads. I mean, just to pick 2 sigma, just to say, okay, we'll use 2 sigma -- I just wonder if we could risk-inform that somehow.

MR. HISER: In the next couple of slides, I'm going to talk about some of the things we're going to do to look at the safety impacts of this.

CHAIRMAN RICCARDELLA: Okay. Thank you.

MR. POEHLER: Another task is to determine the default values for inputs that are not available. Typically, you have the information on the chemistry, but the E900 trend curve uses manganese and phosphorus, which is not needed for the current Reg Guide. Most plants should have this data on their materials. But, in case they don't, you know, what defaults do you use? And that could even apply to copper and nickel for some occasions.

And also, things like irradiation temperature, which some plants have a really good idea what it is, and I'm not sure they all do. They didn't have to have that before for the current Reg Guide. So, that's another major task.

And the final piece of this is to actually write the Draft Regulatory Guide for internal review. But the second four bullets would be probably the

major elements, technical elements, that go into that Reg Guide.

Okay. Now I'm going to turn it over to Dr. Allen Hiser to talk about the oversight group activities.

MR. HISER: Okay. Thanks, Jeff.

Now the oversight group looks to provide guidance and direction for the overall effort. Numbers of the group are from both Research and the Office of Nuclear Reactor Regulation to, you know, a Branch Chief in each office who has cognizance over the vessel integrity issues. And also, we have a Branch Chief who has a deep history. So, he's included as well. And we have three SLs in the two offices, the materials SL.

Responsibilities of the oversight group are listed here. One is to recommend implementation options. So, we take the results from the working group, products, determine or recommend ways that this could or should be implemented for plants. And I'll talk a little bit more about that in a couple of slides.

The main thing is we're looking to assess adequate protection aspects of changing the embrittlement predictions. And that really is one of

the key things that we need to sort through.

And finally, we will identify/recommend if there are any needs for rulemaking. As Jeff mentioned, the PTS rule, 50.61, has Reg Guide 1.99, Rev 2, methodology embedded within the rule. If the Reg Guide were to be changed, how does that impact the need to change the 50.61?

Next slide.

We lost some of our colors. This was supposed to be a timeline. On the printout, there's actually an arrow. Yes, here you go. I noticed that yesterday; the screen drops some of the colors.

This is clearly not a linear trace, and it just hits on some of the important past milestones and future dates of interest.

The Reg Guide, as was mentioned previously, was issued in 1988. So, the next gap there takes us to 2019 with the research report. The entire rest of the timeline is an equivalent 31 years. The items that are on the top represent plants where we think the fluence make exceed 6 times 10 to the 19th neutrons per centimeter squared. We've used that sort of as a trigger point where, from the charts that Dan showed, at least for plate materials we may be getting a deviation that's too much. I think that's

on the order of, I don't know, 40-50 degrees Centigrade.

So, in this case for Turkey Point Plant, which you've heard the SLR, I guess the whole Committee heard about the SLR application and our review. We expect that their surface fluence for the vessel will exceed 6 times 10 to the 19th somewhere in 2025. Turkey Point, the 1/4T fluence will exceed that level in 2044.

CHAIRMAN RICCARDELLA: I thought long and hard to try to figure out what "PTN" stood for. Thank you.

(Laughter.)

MR. HISER: That is their name for their plant.

CHAIRMAN RICCARDELLA: I know.

MR. HISER: I think the alternative is not maybe as friendly.

Then, in 2048, Surry Unit 2, the surface of the vessel would exceed 6 times 10 to the 19th. So, in general, P-T limits are one of the main areas of concern that we have. Twenty-five years is really the point at which we would need to have something in place to satisfy Turkey Point's needs.

Surface fluence is important for PTS. At

least from the information we have today on Turkey Point, they have a significant margin for their plate and base materials for PTS.

CHAIRMAN RICCARDELLA: But, as I understand it, Reg Guide 1.99 doesn't really apply to PTS, does it?

MR. HISER: The methodology, the chemistry factor times fluence factor, the credibility criteria, all of that was built into 50.61.

CHAIRMAN RICCARDELLA: I thought it was embedded. It thought the PTS rule had a different irradiation.

MEMBER BALLINGER: They used a different correlation.

MR. HISER: 50.61(a), the alternate PTS, has a different correlation.

CHAIRMAN RICCARDELLA: Ah, okay. Okay.

MR. HISER: Yes, but the original, which changed actually after the Reg Guide was changed in I believe 1991-92, so that it would have coherency with the Reg Guide.

MEMBER BALLINGER: If the criteria was 3 times 10 to the 19th, how far would this shift to the left?

MR. HISER: Turkey Point would shift a

bit.

MEMBER BALLINGER: A bit?

MR. HISER: Yes. Maybe to earlier than --

MEMBER BALLINGER: Maybe to now?

MR. HISER: Yes.

(Laughter.)

MEMBER BALLINGER: Yes.

MR. WIDREVITZ: We would have a lot more plants right now and soon.

MR. HISER: I think Turkey Point may have about the highest fluences of what we expect to see. Surry also had --

CHAIRMAN RICCARDELLA: Implying they don't have real bad chemistry, is that --

MR. HISER: Referring back to Dan's charts, he shows for welds that there doesn't appear to be an adverse trend at high fluence. The materials that are limiting materials for Turkey Point are welds.

CHAIRMAN RICCARDELLA: Okay.

MR. HISER: The base materials, there is a significant margin.

Okay. So, that's on the top where we need to worry about the plants and we need to make certain that we have the best methodology in place that we can

come up with to estimate embrittlement trends. The bottom bullets, starting in 2025 through 2032, represent where we will get additional data. 2025, the PWR Owners Group has put together a Supplemental Surveillance Program, the PSSP, and those capsules will be coming out in, I guess somewhat after 2025, but that data will become available in the late 2020s.

Turkey Point is scheduled to withdraw a capsule in 2026, and it would be tested shortly thereafter and the data would be available for Turkey Point, again, the highest fluence PWR. That data will cover their subsequent license renewal fluence regime. So, that will give them data, plant-specific data, to satisfy their needs.

Surry Unit 1 will pull a capsule in 2027. Surrey Unit 2 in 2032. Those are the capsule withdrawal dates. The data availability, obviously, will be somewhat after that. So, there will be data available for the initial SLR plants.

Okay. Next slide.

Now, in terms of the activities of the oversight group, I talked about assessing the safety significance. We're looking at both the safety significance of deviations in prediction. So, if you underpredict the embrittlement, what is the impact for

PTS and for P-T limits? We're looking at doing FAVOR runs to try to assess through-wall crack frequency and leveraging some of the analyses from the PTS reevaluation. That was what was used to develop 50.61(a). As I mentioned, if you have a shift in the RTndt, maybe you underestimate the shift. What's the impact on through-wall crack frequency?

In addition, we're looking at a plant impact study on a subset of plants. So, looking at what we call a smart sample with features such as high fluence, high copper, the plants that would tend to have the highest embrittlement. We just want to understand what the impact of using the E900 trend curve would be on the embrittlement estimates for those plants.

And we will use the working group's update recommendations and criteria that had been developed previously. Using all of these results, we'll look at what implementation options we should have for the Reg Guide. And the gamut could be from not making any change to the Reg Guide, choosing to modify the Reg Guide, and then, implement it on all plants, no plants, some subset of plants, to be determined. We have a lot of work to do to get to that point.

Next slide, Jeff.

And looking at the milestones, I guess probably the ones that I would zero-in on the most would be a public meeting with stakeholders in the middle of February that we're looking at, where we would discuss the results that we have to date and talk about our options going forward.

Two weeks after that, we would have a decision point for whether we continue the work to revise the Reg Guide and implement the new embrittlement trend curves or whether we would terminate this effort. Assuming that we continue with the Reg Guide revision, then we would expect to have a Draft Reg Guide for internal staff review the end of April. So, that's five and a half months away.

And next slide.

MEMBER REMPE: I think you really mean 2020 on that day, right?

(Laughter.)

MR. HISER: Thank you.

MEMBER REMPE: Yes.

MR. POEHLER: My bad. I put that line item in there.

MR. HISER: Revisionist history.

MEMBER BALLINGER: I'm trying to get a handle on the longer term. What happens after April

30th, 2020? The internal review, how long does that take? In other words, when can we get surety, if you want to use that word, on what's going to happen?

MR. HISER: That's a good question. We have an internal review process overall. I mean, at this point, this would be the working group and oversight group recommendation going forward. I would expect we'd have a lot of internal discussions.

MR. IYENGAR: So, once we have the draft and it's reviewed by our colleagues in NRR and us, we'd have a Draft Reg Guide and it goes to the Reg Guide Branch. And it goes through a process of releasing it for public comment. And it receives public comment to give them 60 days. And then, finalize it. And then, issue it.

It could typically range from four to six months, and depending on the public comments, if the public comments are extensive and need resolution time, it might take longer. But that's the timeframe we are shooting for.

And one of the reasons for this engagement with you all is to gain some efficiency upfront. We released the TLR publicly in August. So that there's enough public awareness of this topic and we have this engagement. So, as we move along, we will probably

gain some efficiency in the Reg Guide process.

MEMBER BALLINGER: So, my high school math tells me that the end of 2020 is probably a good date to think about.

MR. IYENGAR: Well --

MEMBER BALLINGER: Because you said six months and I just added six to four, got 10, assumed it was 12.

MR. IYENGAR: You are a professor. So, you certainly want to pin down the students on dates.

(Laughter.)

I certainly don't want to make the commitment, but I just typically give an average time.

MS. LUND: Yes, and I would be remiss if I also didn't mention that, you know, the area of regulatory guidance is subject to some Executive Orders that have come out recently as well. So, we and other agencies are also trying to see if that impacts any of our processes as well. We hope not. I mean, because we already put out our guidance for public comment and things like that. But that's another thing that we're also engaged in as well, is responding to that.

MEMBER BALLINGER: So, sometime before Dan has white hair?

MR. WIDREVITZ: If it goes that way, for certain.

CHAIRMAN RICCARDELLA: I guess speaking for myself -- and this isn't for the Committee, just my personal opinion -- and I understand we have to be cautious not to put an undue burden. But to be in a situation where we have a trend curve based on 177 points that was published in 1988, and now we have 1900 data points that show there is some inadequacy, I mean, to not revise the Reg Guide just doesn't make sense.

MS. LUND: And we heard that, you know, and we agree with that. Okay? And I think that we've got the working group together to address that.

CHAIRMAN RICCARDELLA: Yes, yes.

MS. LUND: And I think that what you see here is I think a fairly assertive schedule to address that with the working group. Trying to put an actual end date to this obviously takes it out of the working group's hands because they don't actually process the Reg Guides. But I think that we find it important, just as I think the Committee finds it important as well. So, I can tell you that.

MR. HISER: Yes, I guess, you know, the point I'd make from the timeline, 31 years ago we

revised the Reg Guide. This is not something we do frivolously or every five years or 10 years. So, this one, we really want to make sure that we get it right because this may be the last opportunity that we have.

CHAIRMAN RICCARDELLA: There will be more data another 10 years from now.

MEMBER KIRCHNER: There will be more data from your capsules, yes.

MR. HISER: Compared to 1900 data points, there won't be too many. But the one advantage is a lot of that data will be high fluence. So, it will help us to understand the trends that Dan showed.

MEMBER KIRCHNER: And plant-specific with material, understanding the materials at high fluence.

MR. HISER: Yes, that's correct.

And I think that was the end of our presentation.

MEMBER KIRCHNER: Well, Allen, may I ask a question? How are you going to determine change in through-wall crack frequency as a function of shift in RTndt? My question is, are you going to take samples that are irradiated, and then, test them? How does one go about developing a database to change the estimate of frequency of through-wall cracks?

MR. HISER: Now this will be using

probabilistic fracture mechanics, the FAVOR code.

CHAIRMAN RICCARDELLA: Let me just say, through-wall crack frequency under the PTS analysis is sort of a surrogate for vessel failure.

MEMBER KIRCHNER: I know, yes.

CHAIRMAN RICCARDELLA: So, they're doing it. They're not saying "observing through-wall cracks". They're saying, if we have a thermal-shock event --

MEMBER KIRCHNER: Right.

CHAIRMAN RICCARDELLA: -- what's the probability of a vessel fracture?

MEMBER KIRCHNER: Right.

CHAIRMAN RICCARDELLA: Really is what it says. That's what they mean. It's not an NDE kind of thing. Now it makes some assumptions about the existence of flaw distribution, of a preceding flaw distribution --

MEMBER KIRCHNER: Right, flaw distribution. Right.

CHAIRMAN RICCARDELLA: -- in the vessel, but they're very small compared to through-wall.

MEMBER KIRCHNER: It's not my field. But it's a question that's motivated in part, just technical curiosity. I'm just trying to think, so on

what basis now are you going to change this frequency curve, or however you capture this?

MR. HISER: What the calculations will do, we'll look at defining a pressure-temperature limit curve that's allowable in accordance with ASME requirements.

CHAIRMAN RICCARDELLA: Right, with the code, yes.

MR. HISER: Right, with the FAVOR code. Then, we'll assume that is actually an error by 50 degrees. The real material is -- or some number of degrees -- so, the real material is actually more brittle than what is assumed in the P-T limits.

CHAIRMAN RICCARDELLA: Right.

MR. HISER: And therefore, we will run the FAVOR code to see what the through-wall crack frequency is for that -- I hate to use the word "error" -- but that miscalculation of delta T. And as you do that over a range of delta T incorrect calculations, then you will understand what the impact is.

MEMBER KIRCHNER: But how is the FAVOR code benchmarked and validated to use for this purpose?

MR. WIDREVITZ: So, the FAVOR code, as I

think some of us have experienced it, is a wildly complicated code. So, to answer in detail, I think we would have to think about it. But the short answer is a lot of similar calculational work was done with FAVOR as the basis for the 50.61(a) rulemaking. And so, we would likely be building on that schema to produce these results. So, this isn't like page engineering we're doing here.

MEMBER KIRCHNER: Maybe we have some additional input.

MR. TREGONING: This is Rob Tregoning from Research.

We've done extensive validation efforts over the years on FAVOR. I would argue that it's not wildly complicated. We have codes that we use in the agency that are much more complicated than the FAVOR code that we base our decisions on.

(Laughter.)

And we've validated it in a variety of ways. We've had small-scale testing and experiments, large-scale testing and experiments, experiments specifically designed to simulate thermal-shock events, experiments with lower transients. And then, there's been extensive round robin benchmarking internationally. Other countries have similar codes.

We've had a number of benchmarking and international round robin exercises that have been used to benchmark the FAVOR code. And currently, now we are doing an official, more rigorous sort of Part 50 V&V effort, so that we can bring our verification documentation and quality assurance up to typical regulatory standards.

CHAIRMAN RICCARDELLA: Okay. Thank you.

Just another question. As I understand it, the FAVOR code or what was used for the PTS rule used a different correlation than Reg Guide 1.99, Rev 2. How does that compare to the E900? I mean, is it about the same? Is it more conservative, less conservative than --

MR. WIDREVITZ: To handle this one, over the span of which the base data that both interpolate, the two agree fairly well. However, E900 has a lot more data. It has international data. It has some higher fluence. But over the span where they're both interpolating over the same data, they compare quite closely. Statistically speaking, if you saw the statistics in that range, you wouldn't be able to guess which one was which.

MR. IYENGAR: May I just add to what Rob had mentioned? This code FAVOR is not only our flagship code, it's one of the best codes that's been

used extensively by not only us, but also industry. And there's been a lot of good comments on the use of the code.

I do want to tell you that I just fully agree with what Rob mentioned, and these recent efforts that we are undertaking actually had enabled our staff to run these codes across the agency better. And we have even a developer training for this code where some of our staff can actually intensely develop and change stuff, if the need arises.

And I do want to tell you, also, DOE has asked us to use this code to benchmark the Grizzly code that they are using for similar type of analysis. And the Japanese have, with Mark Kirk, the lead earlier on, benchmarked this code against the Pascal. And so, if there is any code that has been on the component integrity side using probabilistic fraction mechanics that has been used extensively and been fruitful, it's FAVOR, I think No. 1 choice. And next comes xLPR. Just so that I don't want to make Dave Rudland happy here.

(Laughter.)

MEMBER MARCH-LEUBA: This is thinking outside the box, somebody that doesn't really know what's going on in this area. But I understand the

industry is really concerned that you are reopening the Reg Guide and doesn't know how it is going to hit them. I mean, if I was a plant operator, I would be scared. Okay?

CHAIRMAN RICCARDELLA: Industry is going to be talking.

MEMBER MARCH-LEUBA: I know. I know. But it seems to me, by looking at your timeline and everything, that is only going to apply to one or two PWRs well into the thing. And what I'm thinking is, could this be resolved by a penalty for those two plants?

MR. HISER: Well, that's partly what we want to assess. The couple of plants that were identified on the timeline are those that have high fluence.

MEMBER MARCH-LEUBA: Yes.

MR. HISER: So, we know that they're in an area that on Dan's charts would indicate that there's a potential if you use non-conservative predictions --

MEMBER MARCH-LEUBA: But I thought you said --

MR. HISER: What we want to do is understand, if we were to implement this, what is the impact on plants.

MEMBER MARCH-LEUBA: I thought you said that one of the plants is not really there because it's limited by the welding, which really is not effective.

MR. HISER: Correct.

MEMBER MARCH-LEUBA: I don't know. I'm typically not an industry applicant, but if I was in this area, I would feel more confident if, instead of reopening everything, we just give a penalty to the two or three cases where it really matters.

CHAIRMAN RICCARDELLA: But do we want to perpetuate a 30-year-old technology in our Reg Guides?

MEMBER MARCH-LEUBA: I'm just putting it out there.

MR. HISER: I don't think this is -- I mean, we have the same concerns as the industry. I mean, we don't want to penalize plants if their predictions are reasonable currently. From what Dan showed up to maybe 3 or so times 10 to the 19th, we seem to get good predictions from Reg Guide 1.99. One possibility would be to say, if you're above that fluence, you need to use this other model. I mean, there are many ways that this can be implemented, and this is not something that staff will just edict. We have a public meeting the middle of May that we're

looking at. We will have lots of public input and industry input on this.

MEMBER MARCH-LEUBA: My concern is that we might elevate this to too much of a problem, when it really may not apply to everybody.

MR. WIDREVITZ: And I just wanted to just provide a little bit of the new reactors perspective, because, until very recently, that's the only thing I was doing. And we are here in the presentation -- you know, our primary concern is the operating fleet. It exists. It's real. They're moving these very high fluence zones. As a new reactor person, Reg Guide 1.99 gives me very, very inaccurate predictions, to the point that I really don't know from the Reg Guide what's happening because the Reg Guide was concerned with a different body of chemistries.

And so, it really isn't just these high fluences where the Reg Guide is going to produce bad results; it's also things like the low copper modern materials that all new plants, including the AP1000, are going to use. And so, whether that's significant -- you know, I think Allen put it very well -- like how many plants? How significant is that going to be? But we have to think about the full spectrum of inaccuracies.

CHAIRMAN RICCARDELLA: And in most cases, it's overburdensome. It can be overburdensome.

MR. WIDREVITZ: Well, for new reactors, it's a large underprediction, but their ultimate shift might not be that serious anyway because their materials are so good.

CHAIRMAN RICCARDELLA: Right.

MR. WIDREVITZ: So, it doesn't matter if your prediction is that far off. And it's not a single modal problem.

CHAIRMAN RICCARDELLA: Yes. Well, I think we're about 10 minutes behind schedule and we have --

MR. RUDLAND: Just a quick question, Pete, or just a quick comment. And I think that what you were pointing out is that one of the reasons why we want to do this assessment is because there could be benefit to going to an updated trend curve, also. It could actually help industry save money. So, we want to make sure that we assess the whole range of whether it's going to be a safety problem, but also it may be a benefit. So, we may want to make it a voluntary effort for them to do that if they can get a benefit out of it.

CHAIRMAN RICCARDELLA: Okay.

MS. KHANNA: So, Meena Khanna.

Go ahead. Do you want to say your name?

MR. RUDLAND: Oh, sure. I'm Dave Rudland.

MS. KHANNA: So, just to add onto what Dave Rudland said -- and I think this has been a really good discussion -- I think that's going to be the challenge for the staff, right? They're going to be coming up with options for management to consider. We also have to be aware of the fact that we have forefitting and backfitting guidance out there now that the Commission has relayed to us. So, we'll have to factor that. And as Dave mentioned, there may be opportunities where the Commission -- I'm sorry -- where the licensees will be able to get some benefit, but, then, we'll have to look at the other venue, too.

We'll have to look at, if we're adding additional burden to the licensees, we'll have to go through the Commission's policy now on MD 8.4. So, that's all going to be part of the assessment. So, great questions. Please know that that will be considered thoroughly by management before any kind of recommendation goes forth.

CHAIRMAN RICCARDELLA: Okay. So, do we want to change speakers and listen to what EPRI has?

MR. HARDIN: Good afternoon, everyone.

My name is Tim Hardin. I'm with the

Materials Reliability Program at the Electric Power Research Institute, and appreciate the opportunity to come and share our perspectives on this very important issue.

I wanted to talk about a number of things. Hearing the staff's immediately prior presentation, it was very interesting that we were not aware of the positions that the staff was going to take. And so, I think there's a lot of overlap, and I don't need to dwell on some of these issues.

I do want to talk about the upper shelf energy prediction model, the shift model, or the delta T 41J model and some of the scoping study that we've done on the impact that it will have on materials when you go from Reg Guide 1.99, Rev 2, shift prediction model, to the E900 shift prediction model.

I do want to stress that this presentation is from the EPRI staff. It should not be regarded as representing an industry position of the U.S. utilities, although they have been briefed on it.

So, in July, with the release of the TLR, EPRI reviewed the TLR and provided some comments to this Subcommittee on August 22nd. And since that, as I mentioned, we have studied the potential impact, and I want to summarize that in the next slides.

Just briefly, we found the TLR to be succinct and thoroughly documented and the recommendations to be supported by the analyses that were presented in the TLR. We did have some comments, specific areas that we pointed out, some disagreement, but, by and large, the conclusions we think are accurate.

But we also thought that the TLR and the data in the TLR support a phased implementation of any change to the Reg Guide. And the conversation that we just had in here was very much, I think the thinking is along those lines.

So, on the upper shelf energy prediction model, what we were going to say is that, you know, in the August 22nd meeting, we mentioned that EPRI has done some research in this area. And we developed a revised upper shelf energy decrease prediction model. It was not because we thought the Reg Guide was not conservative so much as we were concerned with the lack of technical basis for the existing model in the Reg Guide.

And so, we developed this new prediction model in MRP-414 that bounds 2 sigma of the data. But, then, when we evaluated the impact of this new model on the fleet, we found that at 80 years the

number of vessels that have materials that are predicted to fall below 50 foot-pounds is about the same, if not exactly the same, as under the Reg Guide. So, it wasn't clear that adopting this new model would really achieve anything. And so, the only point I wanted to make was we do not believe there is any benefit, a significant safety benefit, to revising the upper shelf model, and we don't think it should be. And it sounds like there's agreement there from the staff, since this is not an area of focus in their current effort.

Now, on the shift prediction model, we note that the staff, as we heard -- and I have quoted some lines out of the TLR here -- that the non-conservatism of the Reg Guide starts in the area from 3 to 6 times 10 to the 19th. It seems that the emphasis today has been on 6 times 10 to the 19th, which we would understand and agree with.

And because the Reg Guide is used for embrittlement predictions to show compliance with 10 CFR 50, Appendix G, then the appropriate metric to look at in terms of deciding who is affected, and who needs to implement a potential change, would be the 1/4T fluence for the vessel, because that's the fluence that is used in generating pressure-

temperature limit curves, per ASME Section 11, Appendix G.

So, based on that, TLR's assessment of where the Reg Guide starts becoming non-conservative, if you look at the BWR fleet, we have this report that was recently generated, and I believe the staff have it for review, BWRVIP-321. It's the plan for extension of the integrated surveillance program into the second license renewal period.

Most of the plants, the BWRs, have 1/4T fluence, and the range is about 1 to 5 times 10 to the 18th. And some of the higher fluence BWRs have fluences as high as 9 times 10 to the 18th. But that's substantially below the fluence at which the Reg Guide starts becoming non-conservative at 3 to 6 times 10 to the 19th. So, we do think that the BWR fleet could be safety exempted from any change, and they could continue to use the current Reg Guide shift prediction model through the 80-year life.

PWRs, of course, fluence is considerably higher and there are going to be some that are impacted in that area of where the Reg Guide is potentially non-conservative. Now, in order to make a prediction of what the materials would, you know, the shifts would be, you need to know what

embrittlement prediction model is going to be used. And coming into this meeting, we did not know what the staff was going to recommend. So, we thought the two logical choices would be either E900-15 or EONY, which is the trend correlation that's adopted in the alternate PTS rule.

So, we made a chart here comparing the two. E900, developed in 2015, an international dataset of 1878 data. The result of a consensus process; whereas, EONY was developed 10 years before with only 855 U.S.-only data, as a result of an NRC contractor effort. And so, our preferred recommendation would be for ASTM E900-15, and I see that the staff agrees with that.

So, what we've done is we've assumed that it's E900-15 and taken a look at what happens to specific materials if you change from a prediction using the Reg Guide to E900. So, on the following plots we have plotted the difference, where we take the prediction using E900 and subtract the prediction of the shift using the Reg Guide. And so, a positive difference above zero would mean that there would be an increased shift due to the use of E900; a negative difference means that the shift would decrease and that E900 would provide relief in comparison to the

Reg Guide.

We looked at 80 years of operation. That's the fluence that we assumed. And we looked at two different groups, high copper and low copper, since they behave very differently.

So, this is the first. This is the low copper comparison, where, again, you have anything above the zero line indicates that, if you went from the Reg Guide to E900, the shift would increase, and below the line it means that the prediction would be reduced.

So, the first takeaway is the base materials, the plates and foragings, would pretty much see an increase across the board, but the welds would see a mixed story. So, there would be some improvement and there would be some penalties for those materials.

And again, this is the mean shift plus 2 sigma. And from 18 to 19 is the BWRs, and higher than 19 is the PWRs. This is the low copper. For the high copper --

CHAIRMAN RICCARDELLA: Each of these are actual plants at 80 years or?

MR. HARDIN: This is projected --

CHAIRMAN RICCARDELLA: Projected.

MR. HARDIN: -- fluences at 80 years.

CHAIRMAN RICCARDELLA: But each data point represents a plant, basically?

MR. HARDIN: Yes.

CHAIRMAN RICCARDELLA: Okay.

MR. HARDIN: From the surveillance database. We took that material and just extrapolated.

And then, for the high copper steels, a little bit of the same story. Generally, the plates increasing across the board. There are a few plates that would benefits. But the welds are very much mixed. A lot of the PWR welds would see a significant benefit if they went from the Reg Guide to E900. So, I offer that information for consideration.

Now, considering how this would impact a specific vessel and its P-T curves is a little bit more complicated, because, as we saw in those plots, some materials are going to increase in shift; some are going to decrease, and often that will happen within the same vessel. So, you're not going to know what the impact on the vessel is until you sit down for each material and do the calculation, and then, you take the highest adjusted reference temperature for that vessel and, then, compare it to the adjusted

reference temperature that is currently used as the basis for the P-T curves, the current P-T curves.

So, the vessel-specific evaluations have not been done. And we can't do them really until, well, I said here until we know what prediction model we're going to use, but now I think we know that, E900. And also, as the staff alluded in their presentation, how is surveillance data going to be accounted for? And so, until we know the proper procedures to use for that in the new Reg Guide, we won't be able to sit down probably and do a fully-informed vessel-specific evaluation.

But what's clear is that performing that evaluation, a plant going out and having to do that evaluation would be a significant burden. And if their 1/4T fluence is below the level at which the Reg Guide is non-conservative, then there's really no benefit to that. So, we're offering that for consideration, some sort of metric at the 1/4T for screening on who has to take action and who does not take action.

So, the conclusion and recommendations. No change is recommended to the upper shelf energy mode. E900-15 is the preferred alternative shift model. And BWRs appear to be able to use the existing

Reg Guide shift model through 80 years of operation; PWRs would, of course, have to be screened according to their 1/4T fluence. And it will be helpful to the staff, to the plants, as they assess -- you know, many of them are considering second license renewal. Well, they need to look ahead and see what their operating envelope is going to be. And so, a timely understanding of what these new requirements are going to be will help their efforts in deciding if it's feasible to go for a second license renewal.

I think that's all I had. Are there any questions?

MEMBER MARCH-LEUBA: Yes, I have one.

MR. HARDIN: Yes, sir?

MEMBER MARCH-LEUBA: What type of burden is there for a plant if the Reg Guide is revised? Is it a burden on the paperwork to calculate the new numbers and send it to the NRC? Or the burden is because, if they calculate a number that is bad, they have to change their core and modify their peaking factors and --

MR. HARDIN: No, it's not a matter of changing the core, but it's a very expensive calculation.

MEMBER MARCH-LEUBA: So, the burden is on

the paperwork and --

MR. HARDIN: And then, what happens is, you know, you not only have your P-T curve, so you give it some administrative paperwork of your P-T curves, but, then, you take those P-T curves that you get from your vendor that does the calculation, and then, you have to change plant procedures and you have to conduct training of the plant personnel to implement those new --

MEMBER MARCH-LEUBA: Say that I'm a BWR. I'm in the 5 times 10 to the 18.

MR. HARDIN: Yes.

MEMBER MARCH-LEUBA: I'm going to calculate numbers with a new correlation. They're going to be the same as the old one, hopefully. Then, what is the burden?

MEMBER PETTI: I don't think that's -- no, that's not the point. He said the BWRs aren't affected. The changes will only affect PWRs, a subset of which -- and we really won't know because of the different materials until you actually have to -- you have to try before you buy.

MEMBER BALLINGER: And how often are the P-T limit curves calculated on a kind of sort of routine basis for a plant? In other words, at some

point during the going forward, would there be a case where a new P-T limit curve would be required in any case? And so, this would all get factored into that?

MR. HARDIN: Well, certainly the P-T curves are recalculated whenever a plant withdraws a surveillance capsule, and then, has to consider that data.

MEMBER BALLINGER: So, is that the same calculation that would be done?

CHAIRMAN RICCARDELLA: Yes. I mean, they're going to -- I'm trying to understand the difference. If they're going to do a calculation when they pull a surveillance capsule, whether they use the old trend curve or the new trend curve, there's no more of a paperwork burden, right?

MR. HARDIN: That's right. That's right.

CHAIRMAN RICCARDELLA: The paperwork burden is about the same.

MR. HARDIN: It would appear to make sense to use --

CHAIRMAN RICCARDELLA: Yes.

MR. HARDIN: -- the new one, if you're --

MEMBER BALLINGER: So, is it safe to say that all the plants would have withdrawn, have had occasion to withdraw a capsule between now and going

forward?

MR. HARDIN: I believe that is not generally true.

MEMBER BALLINGER: Not true?

MR. HARDIN: Well, to withdraw a capsule?

CHAIRMAN RICCARDELLA: Yes, sir.

MR. HARDIN: Some plants have P-T curves, I am informed, I am told, that are good through the end of license.

MEMBER BALLINGER: Okay.

CHAIRMAN RICCARDELLA: Yes, yes, yes.

MEMBER BALLINGER: So, that would be a burden?

CHAIRMAN RICCARDELLA: But, for license renewal or subsequent license renewal, the ones we've reviewed, they have a schedule to pull a capsule, right?

MR. RUDLAND: This is Dave Rudland.

It really depends on the plant and whether or not they have pulled their 80-year capsule or not, whether they have pulled a capsule that represents their fluence at 80 years. If they have, then there's no reason for them to pull another.

MEMBER MARCH-LEUBA: Right, but if you issue the new reg, the new revision of the Guide, will

everybody have to do the new P-T curve?

MR. RUDLAND: And that's to be determined. I mean, that's what we're doing as part of our safety impact, is determine how we want to implement this thing --

MEMBER MARCH-LEUBA: Yes.

MR. RUDLAND: -- whether it's for one plant or 94 plants. What does it need to be for? We don't know that yet.

MEMBER MARCH-LEUBA: That's something that the staff needs to -- I mean, for example, for BWRs and they are 5 times 10 to the 18, they don't need to do anything.

MR. RUDLAND: That's right. So, we have to do a safety assessment. If there's no safety, then there's probably no reason to implement.

MEMBER MARCH-LEUBA: Yes.

MR. RUDLAND: Or I should say there's no reason to mandate that it's being used.

CHAIRMAN RICCARDELLA: Reg Guides are mandatory? Are they? They're guidance.

MEMBER BALLINGER: 10 CFR 50, Appendix G --

CHAIRMAN RICCARDELLA: Huh

MEMBER BALLINGER: Appendix G is.

CHAIRMAN RICCARDELLA: Yes, yes. But does Appendix G direct you to 1.99, Rev 2?

MEMBER BALLINGER: Yes.

CHAIRMAN RICCARDELLA: Oh, okay.

MEMBER KIRCHNER: Sometimes things in Reg Guides are incorporated in the -- I'm not the expert on this, but they will be taken almost verbatim, and then, put into like 10 CFR 50 regulations. And then, they have -- yes, right.

MR. HISER: Yes, this is Allen Hiser.

And that's what was done in the early '90s with the PTS rule, was that the procedure in Reg Guide 1.99, Rev 2, was put into the rule. Now the question about -- Reg Guides are guidance documents. They're not regulation. Reg Guide 1.99, Rev 2, was actually implemented using a Generic Letter that asked plants, how will you predict embrittlement? Will you use Reg Guide 1.99, Rev 2, or will you use some other approach? Virtually I think everybody at that point used Reg Guide 1.99, Rev 2. There have, subsequently, been plants that have used, let's see, the master curve approach, and they've used -- no, not .61(a). I think some of the plants have developed their own curves, like the BMW (sic) Owners Group developed curves that were used.

So, the Reg Guide 1.99, Rev 2, is not required, but plants chose to implement it through the GL process.

MR. HARDIN: I'm not aware of any plant that does not use the Reg Guide 1.99, Rev 2, for prediction of embrittlement. I understand the point about Reg Guides being guidance, but this particular Reg Guide is as close to being a rule as it can get.

I just wanted to also correct an earlier statement, with all due respect to Dr. Hiser, that the PWR Supplemental Surveillance Program is an EPRI Materials Reliability Program, a program, not a BWR Owners Group program.

CHAIRMAN RICCARDELLA: Okay. Well, thank you, Tim, for your presentation. You effectively got us pretty close to back on schedule.

So, with that, I'm going to open the meeting for public comments. So, if someone will check to make sure the phone line is open? And while you're doing that, I'll check to see, is there anybody in the room from the public who would like to make a comment?

(No response.)

Hearing none, we'll go to the phone line. Is there anybody on the public phone line? If so,

would you speak up, please, and just let us know you're there?

(No response.)

It sounds like nobody is there. So, I assume nobody wants to make a comment.

You can close the line.

So, we have some time for Committee discussion. Ron, do you want to lead that?

MEMBER BALLINGER: I think we pretty much covered everything that we thought we would be putting in a letter of some kind. We have a draft letter and will be producing another draft tonight --

CHAIRMAN RICCARDELLA: Yes.

MEMBER BALLINGER: -- for consideration of the Committee. But that's about all I would have. Everything has been covered pretty accurately.

MEMBER BLEY: Do you want to summarize here what the main points you would be making in the letter are?

MEMBER BALLINGER: The main points -- and actually, the staff, unbeknownst to myself, the staff has actually come around to our conclusions. And that is that, (a) we should do this. We should reconsider, we should revise the Reg Guide. We should revise it on a schedule which is defined. We should also -- we

can't say much towards implementation, but we suggest that the implementation would be in a very phased approach, so that plants could pick and choose where it was essential that they needed it.

But the fact that we have truth nowadays, as opposed to 187 data points, we have 1800 data points, is a sufficient reason for revising the Reg Guide, especially when you consider subsequent license renewal going forward. Now is the time to do it.

MEMBER BLEY: From what I heard, I think -- I think from what I heard from both the staff and EPRI, it is that no existing plant in a spot at this point in time where the current approach would be non-conservative, such that nobody would have to do anything right now.

MEMBER BALLINGER: If you choose 6 times 10 to the 19th.

MEMBER BLEY: Yes.

MEMBER BALLINGER: If you choose 3, then there are plants that are on the edge. Now, if you switch to the 1/4T --

MEMBER KIRCHNER: Yes, I was going to ask, just for clarification, if you switch to 1/4T --

MEMBER BALLINGER: Yes, I'd have to think -- probably not. If we go to 1/4T, then there's

probably 8 or 10 years before -- I'm just guessing now whether Turkey Point would be. Maybe the staff would know or the EPRI folks would know.

MEMBER KIRCHNER: And the current RG 1.99 is inner-surface.

MEMBER BALLINGER: Yes, that's inner-surface.

MEMBER KIRCHNER: Right.

MEMBER BALLINGER: Yes.

CHAIRMAN RICCARDELLA: There was that staff flowchart where the arrow got -- the timeline where the arrow got lost. I thought that had 1/4T and --

MEMBER BALLINGER: Yes, but that was 6 times 10 to the 19th.

CHAIRMAN RICCARDELLA: Yes.

MEMBER BALLINGER: Yes, the fact of the matter is 1.99, Revision 2, that correlation goes awry.

CHAIRMAN RICCARDELLA: At the inside surface Turkey Point hits 6 times 10 to the 19th at 2025, which is essentially five years from now, and at 1/4T, it hits it at 2044.

MEMBER BALLINGER: Yes, the 10th value layer for neutrons is usually 2 inches, roughly

speaking. So, if you would want to go to 1/4T, you've got to drop --

MEMBER KIRCHNER: And EPRI points out that the code, the ASME code, to which, if I read their viewgraphs correctly, Section 11 is 1/4T.

MEMBER BALLINGER: That's for PTS.

CHAIRMAN RICCARDELLA: No. No, no, no.

MEMBER BALLINGER: No?

CHAIRMAN RICCARDELLA: No. The 1/4T is the size flaw you assume when you're developing your heatup/cool-down curves.

MEMBER BALLINGER: Okay.

CHAIRMAN RICCARDELLA: For PTS, I'm not sure what the original rule assumed. That just picked a temperature. The alternate PTS rule uses a flaw distribution and does a probabilistic fraction mechanics analysis.

MEMBER BALLINGER: We're about to get clarification here, I think.

MR. HISER: This is Allen Hiser.

Actually, PTS is the fluence at the clad-base-metal interface.

CHAIRMAN RICCARDELLA: So, that's a quarter inch.

MEMBER BALLINGER: That's not 1/4T.

CHAIRMAN RICCARDELLA: It's quarter inch.

(Laughter.)

MEMBER BALLINGER: It's quarter inch, yes.

MR. HISER: And .61(a) I believe uses the same methodology. It's just within the probabilistic fraction mechanics analysis it uses a flaw distribution. So, you still benchmark it to the clad-base-metal interface fluence.

MEMBER KIRCHNER: And for clarification, Allen, that's how you apply 1.99, at the stainless steel clad inside the ion emitter or where it hits the base metal?

MS. KHANNA: It's the ID.

MR. HISER: Well, at the --

MEMBER KIRCHNER: ID, not the base-metal clad? Okay.

MR. HISER: Yes, Reg Guide 1.99 has an attenuation function. You can plug in a surface fluence, and then, you can get the spectrum of fluences and embrittlements through the wall. The PTS rule uses the stainless steel-to-base-metal interface.

MEMBER KIRCHNER: And when individual plants do their analysis, when you talked about that fourth factor, do they typically at least take credit for the stainless and go in a quarter inch and do an

attenuation?

MR. HISER: The P-T limits use a 1/4T flaw. And for PTS, it's just the fluence at that interface.

MEMBER KIRCHNER: Okay.

MR. HISER: There's no attenuation of it through the vessel wall. It's just where it's benchmarked to is all.

CHAIRMAN RICCARDELLA: Yes. Yes, because you're concerned about thermal shock which affects really small, you know, it affects flaws closer to the inside surface.

MEMBER KIRCHNER: Yes.

CHAIRMAN RICCARDELLA: For the heatup/cool-down curves, you're mainly worried about more gradual through-wall transients, and the 1/4T is the size that you use. But I think what you're saying is that the 1.99, that both the points on your time chart were relevant, the surface one and the 1/4T.

MR. HISER: That is correct. The surface one is more applicable to PTS calculations, in accordance with 50.61. The 1/4T is for Appendix G, 10 CFR Part 50, for pressure-temperature limits.

CHAIRMAN RICCARDELLA: And I have to plead guilty to being one of the people that introduced the

1/4T flaw in Section 3.

(Laughter.)

MR. RUDLAND: This is Dave Rudland. I just want to make another comment.

Dr. Ballinger keeps talking about 3E to the 19. I think the staff spent a lot of time looking statistically at the data, and, you know, well, the mean trend may begin to deviate at 3; it really does not become statistically significant until you get to about 6. And so, we've based a lot of our assessments on the 6 value, and at this point we strongly feel that there's no immediate issue in terms of the safety significance because of that assessment.

Now, again, you can argue about whether the mean or the deviation from mean is significant or not, but in the scope of the scatter of the data I think we really think that, by the time you get to 6, that you have a noticeable shift in the predictions.

CHAIRMAN RICCARDELLA: Because you're using that 2 sigma. As I understand it, the 6 times 10 to the 19th is where the mean curve --

MR. RUDLAND: Goes beyond 2 sigma.

CHAIRMAN RICCARDELLA: -- it goes beyond the 2 sigma.

MR. RUDLAND: And the 3 curve is just

where it begins to deviate from basically the zero line, right.

CHAIRMAN RICCARDELLA: But I'm just wondering if we ought in the process take a relook at that 2 sigma.

MR. RUDLAND: We have. We have. We have so far, at least in the data that we've analyzed, whatever the baseline data had.

CHAIRMAN RICCARDELLA: Oh, I know there's new data that will generate a new 2 sigma, but is 2 sigma the appropriate margin?

MR. RUDLAND: And I was just talking to my old colleague, Dr. Kirk, here about risk-informing those margins. And some of the analyses that we're doing with FAVOR might be able to help us do that.

CHAIRMAN RICCARDELLA: Yes. Good. Okay. Well, with that, we have -- look me look at the overall schedule.

MEMBER MARCH-LEUBA: All the people for the next presentation are next door. So, we just need to tell them to come in.

CHAIRMAN RICCARDELLA: Should we take a -- we don't have a break scheduled.

MEMBER MARCH-LEUBA: No?

CHAIRMAN RICCARDELLA: No. All right.

So, we're right on schedule, 2:30.

MEMBER MARCH-LEUBA: Well, it's barely behind.

CHAIRMAN RICCARDELLA: So, we don't even have to recess the meeting or do I --

MEMBER MARCH-LEUBA: Well, yes, recess the meeting.

CHAIRMAN RICCARDELLA: Recess while we change speakers.

(Whereupon, the foregoing matter went off the record at 2:31 p.m. and went back on the record at 2:40 p.m.)

CHAIRMAN RICCARDELLA: Okay. So, we'll start with, I'll turn the meeting over to Jose for opening comments.

MEMBER MARCH-LEUBA: Okay. So, we are going to be talking about Brunswick's transition to Atrium 11 fuel using the Framatome methods. For the members that were not in the Subcommittee, this is a complicated review, a complex review. We can get confused very easily because at the time Brunswick submitted a license amendment request many of the Framatome methods were not approved. While they have been in the review, most of the methods from Framatome have been approved generically, and we have seen them,

like the AURORA-B AOO or LOCA. So, we've seen all those.

So, you'll be hearing about the plant-specific methods and the generic methods during the whole presentation. That's what the issue is. Okay?

Go for it, Andy.

MS. ROSS-LEE: So, thank you.

Just to introduce myself, my name is M.J. Ross-Lee. I am the new Deputy Director for the Division of Safety Systems.

So, I want to thank you for the opportunity today. As mentioned, we're here to present the staff's evaluation of the Brunswick license amendment request to allow the use of the Framatome methodologies necessary to support transition to Atrium 11 fuel design.

I'll be turning the rest of the introduction over to Andy Hon, who is from the Division of Licensing.

MR. HON: Thank you, M.J.

Good afternoon, Mr. Chairman and Distinguished Members of the ACRS.

I'm Andy Hon. I'm the Licensing Project Manager for Brunswick within the NRR. Today I'm going to give like a three-minute, quick overview in the

public session to check on the project and the status of it.

For Brunswick Units 1 and 2, currently, they are using Framatome Atrium XM10 fuel, which was also approved to operate in the MELLLA+ domain. That integrated both the analysis with GE and Framatome last year, and the Committee endorsed that review.

The licensee submitted a license amendment request about a year ago for adopting the new, advanced Framatome methodology called Atrium 11. They also requested us to a quick turnaround to support their fuel-loading schedule in February next year.

This is the first application of seven new Framatome analyses for this new fuel design. And most of the new methodology actually has been approved just in time for generic use in the Topical Reports. And as far as the specific change request, it is to change the references in the coder table in Chapter 5 of the Tech Spec.

As far as what the staff did in the last year, it's really, for those approved Topical Reports they adopted, we reviewed mostly the limitations and conditions to ensure that they are addressed properly by the licensee. And for one plant-specific stability analysis, we spent most of our energy on

that review. We identified the necessary license conditions for implementation and, later on, enforcement, if necessary.

Our team conducted two audits of the analyses, one in February, one in March of this year. As a result of the audit, we generated 32 requests for additional information, all of which were addressed by the licensee to our satisfaction.

And the license condition for the methodology not in the Topical Report, we identified the necessary license conditions. The licensee responded and adopted those license conditions for implementation, and we'll give you more details later on.

In addition, our Office of Research performed the phased, independent confirmatory analysis of the FSI stability to ensure the analysis by the licensee is consistent. We will give you a summary of that result.

So, the last bullet is really the reason we're here. At this point, we completed our safety evaluations and generated a Draft Report submitted to the Committee to review. We opted here to make a decision, pending any significant comments from the Committee that staff needs to address.

So, that's the status of the project at this point.

And the last slide, I'd like to recognize the members of our team who contributed to this very challenging, like M.J. said, very challenging schedule, and we worked really hard to complete the review by the one-year timeframe. Typically, it takes two years. So, I would like to use the last slide to recognize members.

So, with that, I'm going to save some time and turn it over the time to our licensee to give a non-proprietary summary.

MEMBER MARCH-LEUBA: I apologize. We are going to be even more rushed than just today. Because we started late and we need to finish a little earlier because I would like the opportunity to read the letter in the closed session to verify there is no proprietary information.

So, if we can find the slides? Perfect.

So, we are still in open session. Please go ahead.

MR. DeWIRE: All right. Good afternoon.

My name is Mark DeWire. I'm the Assistant Office Manager, Shift, or the Senior License Holder for the Brunswick Nuclear Station.

I'm here to give you just a brief overview of the Brunswick station. We are a General Electric BWR-4 with Mark I containment. Began commercial ops in 1975-1976 for Unit 2 and Unit 1 with an original license of 2436-megawatt thermal. Completed extended power uprate which brought us up to 2923 megawatts in the mid-2000s. And we're currently on a 24-month operating cycle. And as mentioned, we are on Atrium 10XM fuel with eight lead assemblies of the Atrium 11. We did transition over to Framatome fuel in 2008-2009 for Unit 1 and Unit 2.

We are licensed for the increased core flow. And as mentioned, we did complete the MELLLA+ last year, and we completed them both. And both units are currently operating in the MELLLA+ region now.

The purpose of this is to do a Tech Spec update to Section 565(b), which has our analytical methods. We're going to be revising that section to allowing Framatome methodologies to be used for Atrium 11 fuel. And we're pursuing the Atrium 11 fuel due to improved fuel cycles. The 11x11 array reduces the fuel duty by approximately 19 percent. It has improved channel performance, improved fuel cycle economics, and near and dear to me is the improved debris protection features with BWR fuel.

The following methodologies will be removed from the section in the Tech Specs, which would be the X-COBRA-T and the Cotransit 2 and the GE detect-and-suppress confirmation density. And we will be replacing those with the Framatome methodologies, as mentioned, with the AURORA-B for the transient analysis, LOCA, and control rod drop, and the best estimate enhanced option 3 for the OPRMs.

And that's it for my section. I'll turn it over to Mr. Mike Bloom.

MR. BLOOM: Good afternoon, everybody.

My name is Mike Bloom. I'm the Director of Fuel Management and Design for Duke Energy. So, I take care of the 11 reactors' core design and licensing analysis. For this group, the interest will be the Brunswick Unit 1 and Unit 2, which we work in collaboration with Framatome on for our reloads.

On slides 8 and 9, you'll see a listing of a number of Framatome reports and one Duke report that are included in the license amendment request. And these reports, these are the application of the methodologies we talked about are going into 565(b) and the MELLLA+ and power uprate domain.

MEMBER MARCH-LEUBA: Other than adding these reports to the technical specifications, have

you made any modifications in the LAR? Does the LAR include other modifications other than adding these references?

MR. BLOOM: Sorry, I didn't catch that.

MEMBER MARCH-LEUBA: The LAR incorporates these references in your Tech Specs?

MR. BLOOM: Yes.

MEMBER MARCH-LEUBA: Are there any other modifications of any relevance?

MR. YODERSMITH: Yes, the name is Stephen Yodersmith. I work for Duke Energy.

There as a Note F in one of the Tech Spec tables that was added for DSS-CD. That note is being removed. It was for first-time application of DSS-CD. It allowed you to basically not arm the DSS-CD trip function when you applied it for the first time. So, since, one, we're operating with DSS-CD and, two, we're removing it from the Tech Specs, that note is coming out. It's a very minor change there.

And the only additional change, as Andy mentioned, is we did add a license condition to our operating license, Section B, to incorporate the best estimate, and hence, Option 3 license conditions.

Those are the only changes.

MEMBER MARCH-LEUBA: Thank you.

MR. BLOOM: Okay. I've move on to slide 10. So, on slide 10 is a list of some Brunswick Unit 1, Cycle 23, cycle-specific documents for just in the reload design. These were provided. They are not part of the LAR, but were provided as supplemental information for the NRC to review, so they could see how the methods were applied to an actual reload and be able to do some comparisons between the results from the cycle that was in the methodologies to the actual cycle application.

Slide 11 talks a little bit about our AURORA-B LOCA methodology that we're applying. As Jose was talking about earlier, this particular methodology was not approved generically at the time we submitted our license application. However, it had gone through quite a bit of review, as we already had a Draft SE. So, in collaboration with the NRC, it was agreed that we could reference that Draft SE and Draft Generic Licensing Topical in our initial LAR.

And since then, of course, the final LAR has been approved. And we circled back with any additional changes from the Draft SE and made a supplement in July to our LAR to capture those. And again, we do appreciate the NRC's flexibility for allowing us to do that, so we can maintain our

schedule.

On slide 12 is a discussion on our stability method for both units. Currently, we use the detect-and-suppress solution confirmation density, otherwise known as DSS-CD. As we transition to Atrium 11 fuel for this upcoming outage, we will be transitioning to the Framatome best estimate option 3, with a confirmation density algorithm.

In doing so, we will maintain our current confirmation density algorithm trip. And so, the OPRM subpoints are going to be the same. So, there's really no change for how the plant's going to respond.

Within the LAR, we did provide a sample problem for the Atrium 11 fuel. And we followed that up with, for one of the supplementary documents, the Reload Safety Analysis Report, as a cycle-specific application of that methodology to that unit.

So, 13, we'll talk just a minute about ATWS-I. So, this is a fuel-type-dependent analysis. So, right now, for the resident fuel, which is Atrium 10XM, it's a TRACG-based analysis. As we introduce Atrium 11, we'll be moving to the RAMONA5 Framatome-based methodology for that.

Similar to the AURORA-B, that generic methodology had not been approved at the time. And

so, in this case, it had made it quite as far down the review process. We elected to do a Brunswick-specific methodology application for that. Since then, the ANP 10.346 has been approved, and the methodology that we have is identical to the generic methodology.

On slide 14, it's basically the pathway that got us here today. We submitted our LAR in October 2018. We did have the two NRC audits that were previously discussed in February on best estimate option 3. And then, we followed up in March with an audit over all the methodologies.

Since then, we've been working on the reload in terms of one Cycle 23 reload documents and providing those as they become available.

We responded to the set of RAIs in June, and then, we provided that AURORA-B supplement in July.

Just last month, with the best estimate option 3 methodology, there were some additional licensing conditions that were applied through an RAI. We responded to that in October and agreed to put those into our license.

And now we're here in November with the ACRS full Committee.

MEMBER MARCH-LEUBA: I must say that, for

an LAR of this complication, the first application of methods and plant-specific methods, having it reviewed in this short time, I know for you it doesn't look very short, but it is pretty short.

MR. BLOOM: Oh, I can certainly appreciate that.

MEMBER MARCH-LEUBA: Both the staff and you should be congratulated for having done this job.

MR. BLOOM: Thank you.

And so, like you said, we are looking for the LAR approval here in February, and that's going to support our startup of Brunswick I, Cycle 23, in March of 2020.

That was all I had to present, pending any questions.

MEMBER MARCH-LEUBA: Do the members have any questions in the open session?

(No response.)

Any members of the public want to present a question?

(No response.)

Anybody on the open phone line, would they like to do a question?

Is the open line open right now?

Questions and comments, yes, sorry.

Comments?

(No response.)

Yes, okay. So, hearing none, there are no comments from the public.

Any members want to say any final words in the open session?

(No response.)

So, can you hit the gavel, Pete?

(Whereupon, at 2:55 p.m., the Committee went from open session to closed session.)

Regulatory Guide 1.99, Rev. 2 Assessment Results and Follow-on Activities

November 6, 2019

Introduction

- This presentation summarizes a multi-year effort to thoroughly assess RG 1.99 through a modern data-driven approach, plus the activities underway to address the assessment results.

Today's Presentation

- Regulatory Guide 1.99 Background
- Assessment Results
  - RT_{NDT} results
  - ΔUSE results
  - Credibility Criteria/Plant-Specific Data results
  - Attenuation results
  - Common additions
  - Conclusions
- RG 1.99 Working Group Charter and Activities
- RG 1.99 Oversight Group Charter and Activities

Regulatory Guide 1.99 Background

"Radiation Embrittlement of Reactor Vessel Materials"

- Rev. 2 issued May, 1988.
- RT_{NDT} curves fit to 177 datum. Few data at higher fluences or with lower Cu.
- USE developed as upper-bound curves. Acceptance criteria for USE is in 10 CFR 50 Appendix G.
- The basis for the credibility criteria and use of surveillance data is not well understood.
- Attenuation formula based on dpa studies.

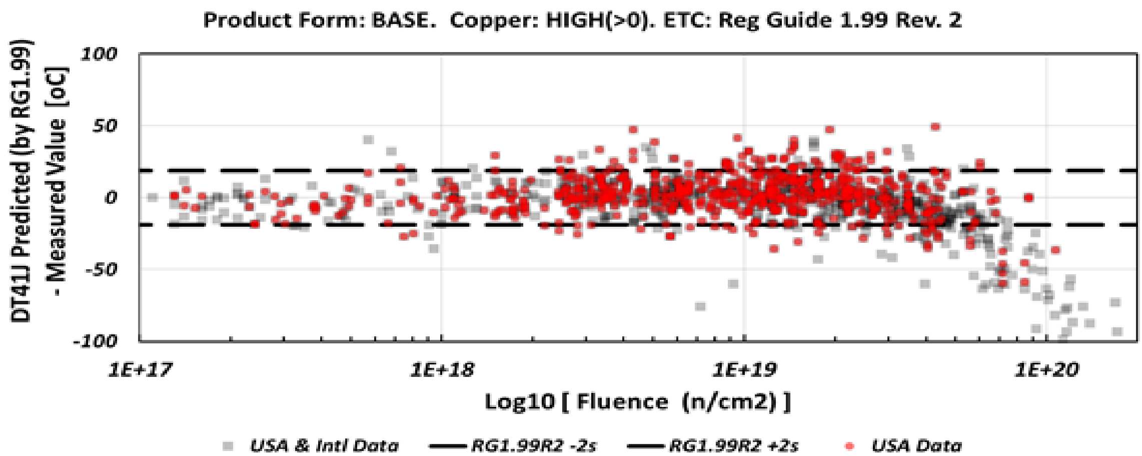
RT_{NDT} – A measure of brittle-ductile transition temperature (considered equivalent to T_{41J});
USE – Upper Shelf Energy

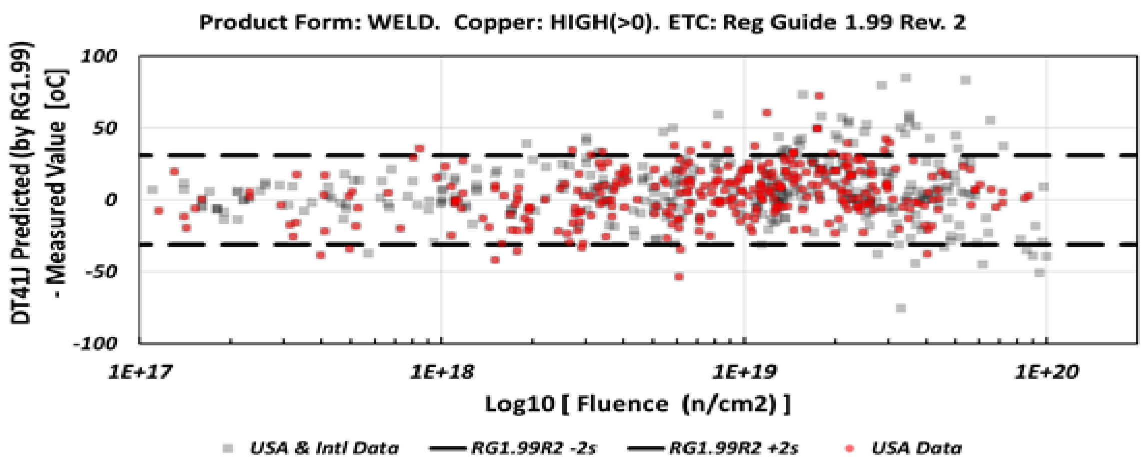
Regulatory Guide 1.99 Background

- ART = unirradiated RT_{NDT} + ΔRT_{NDT} + M (Where ΔRT_{NDT} = shift in RT_{NDT} due to irradiation and M = margin term)
- ART is used to determine fracture toughness when developing pressure-temperature limits.
- The Pressurized Thermal Shock Rule, 10 CFR 50.61, uses the same ΔRT_{NDT} model as RG 1.99.

RT_{NDT} Results

- Assessment based on BASELINE dataset generated by ASTM E10.02.
- Dataset includes domestic and international power reactor data (~55% domestic).
- 1901 data points
- In-depth statistical analysis performed.





Limited weld data at high fluence precludes assessment of whether weld trends with base metals at high fluences.

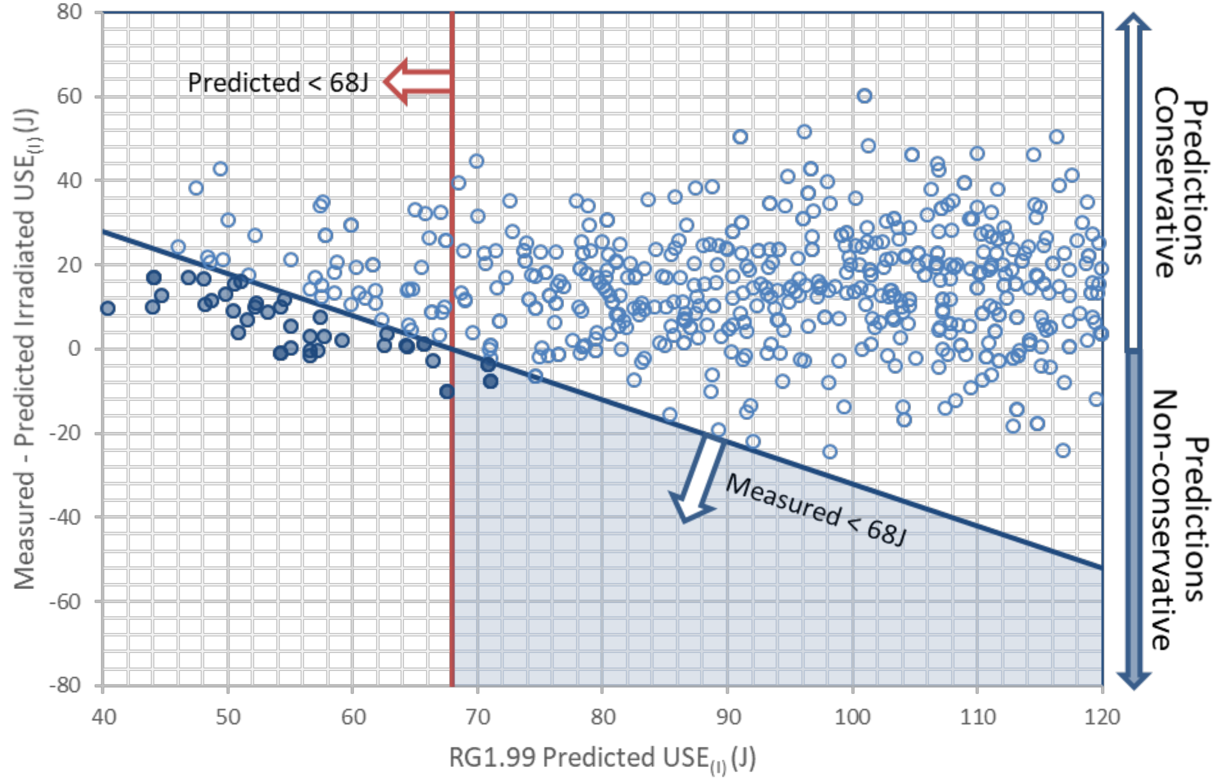
RT_{NDT} Results

- Primary conclusions:
  - Nonconservative high fluence results (base metals)*, becomes prominent at fluences ≥ $6x10^{19}$ n/cm^2.
  - Inaccurate low Cu results
- Secondary conclusions:
  - Standard deviation of ΔRT_{NDT} (σ_Δ) in RG is too low
  - Conservative bias in low-to-mid fluences (burden)
  - Lack of temperature adjustment (inaccuracy)

* Limited weld data available at fluences near or above $1x10^{20}$ n/cm^2 (E > 1MeV)

ΔUSE Results

- Assessment based on REAP dataset merged with properties from BASELINE.
- Dataset includes domestic and international power reactor data.
- 1223 data points.



50 ft-lb = 68J

EMA – Equivalent margin analysis.
Limited number of materials are likely to be measured below 68J (50 ft-lbs) but not have been subject of an EMA.

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

ΔUSE Results

- 19% of materials measured ΔUSE not bounded by RG model.
- Limited number of materials are misprojected to remain above 50 ft-lb and not trigger equivalent margins analyses (EMAs).*
- Minimal impact – the safety criteria supported by USE estimation (50 ft-lb) is known to be extremely conservative.

* - To date no material has failed to be justified by EMA; including many well below 68J.

Credibility Criteria

- RG 1.99, Rev. 2 has five credibility criteria.
- Criteria compare measured data to refit (chemistry factor) RG 1.99 prediction results with a requirement of shape-function of RG 1.99
- If surveillance data is deemed credible, RG 1.99 allows reduction in margin term.
- If data is not deemed credible, data is not considered.
- The criteria typically failed is excessive scatter.*

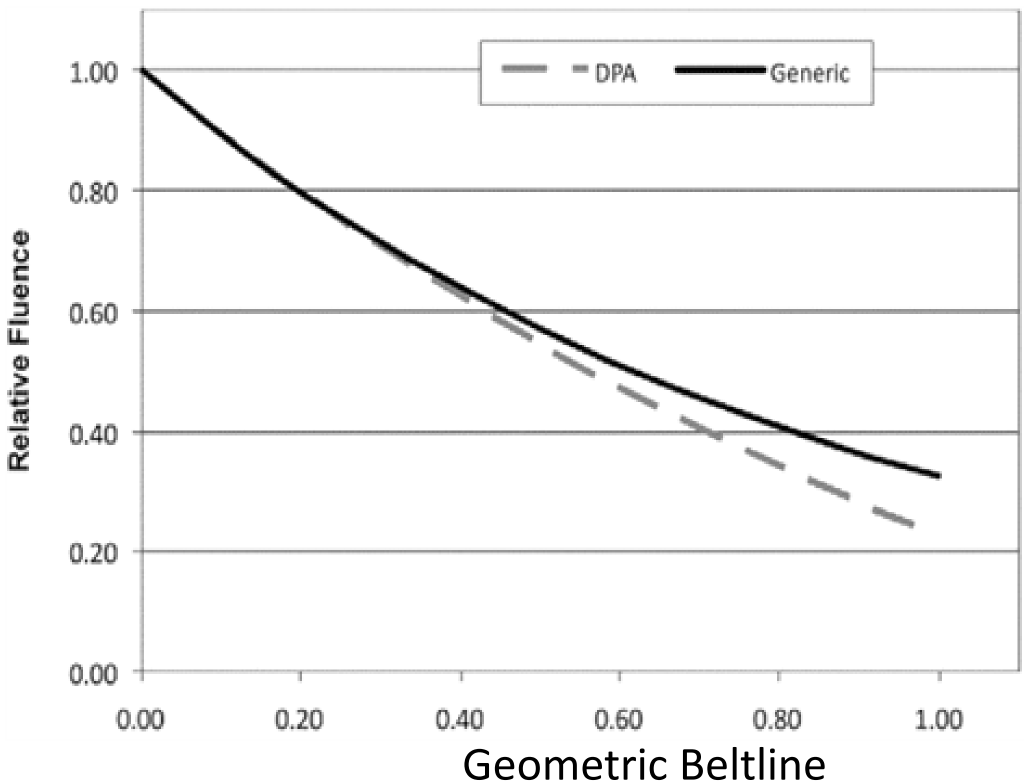
* - One or more surveillance data point outside 2σ where σ is the standard deviation of the ETC (17 °F for base materials and 28 °F for welds)

Credibility Criteria - Issues

- The more surveillance data points, the more likely it is for data to be non-credible due to scatter.
- No apparent basis for reduction in margin for credible data.
- Critical consequence: benefit of fitting predictions to surveillance data is nullified in many cases by credibility criteria that reject data not conforming to the fluence shape-function of RG1.99.
- High fluence and low Cu data not expected to conform to fluence shape function of RG1.99.

Attenuation Formula

- Attenuation formula matches well to modern results. Formula *only works* for areas horizontally adjacent to the active fuel.
- NRC has a research project on determining fluence outside of the beltline region. This will be incorporated in a revision of RG 1.190.



Jones, E. N., "Comparison of Regulatory Guide 1.99 Fluence Attenuation Methods," Journal of ASTM International, Vol. 9, No. 4, 2012, pp. 1-7.

Common Additions

Several practices not addressed in RG have been commonly accepted by NRC. Several of these were explained in 1998 presentation by Wichman et al.*

- Use of sister plant data to supplement plant-specific surveillance data.
  - This is material that is a heat-for-heat match irradiated in another plant.
  - Data is adjusted for difference in irradiation temperature.
- Exclusion of low-fluence outliers from credibility assessment.

*(ML110070570)

Conclusions

- Correcting the nonconservatism in the embrittlement trend curve at higher fluences is the most significant recommendation of the RG 1.99 assessment.
- The credibility criteria should also be revised to make more effective use of plant-specific surveillance data.
- Several common practices not addressed in the RG should be addressed in a revision, such as use of sister plant data, implementation of credibility criteria, degree-for-degree, etc.

Staff Response to Issues Identified in TLR

- In response to TLR, NRC initiated effort to revise RG 1.99.
- Two groups chartered for this effort:
  - RG 1.99 Working Group
  - RG 1.99 Oversight Group

RG 1.99 Working Group Charter

- The working group's primary task is to develop a revision to RG 1.99, Rev. 2 that will address the recommendations of the TLR.
- Prioritization will be given to those recommendations with the most significant potential reduction on safety margin, e.g., the non-conservatism at high fluences is the highest priority.
- USE model in the RG will not be addressed because potentially non-conservative USE predictions have no credible impact on safety as demonstrated by NRC accepted equivalent margins analyses.
- The working group will concentrate on the technical content of the RG rather than regulatory or implementation issues.
- The working group consists of NRR and RES staff. RES staff serves as the lead for the WG.

RG 1.99 Working Group Tasks

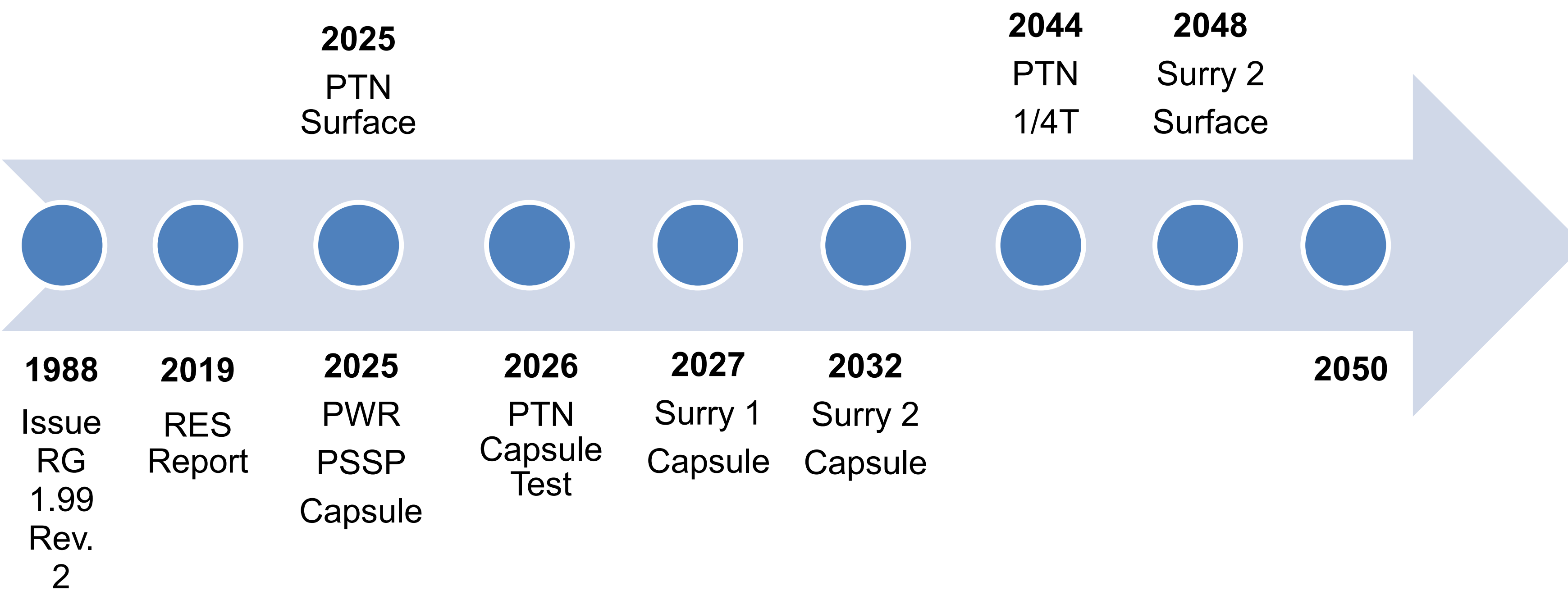
- Recommend an alternate ETC
  - *The working group selected the ASTM E900-15 ETC as the basis for the revision of RG 1.99, Rev. 2.*
- Determine limitations of ETC implementation.
- Determine how to apply surveillance data.
- Determine margins on ETC.
- Determine default values for inputs that are not available.
- Write draft RG for internal review.

RG 1.99 Oversight Group

- Provides guidance and direction for this effort
- Members from RES and NRR:
  - Branch chiefs – RES (1) and NRR (2)
  - Senior level staff – RES (1) and NRR (2)
- Responsibilities:
  - Recommend implementation options
  - Assess adequate protection aspects
  - Identify/recommend need for rulemaking

Timeline

Fluence Exceeds $6x10^{19}$ n/cm^2



RG 1.99 Oversight Group Current Activities

- Determine criteria to assess safety significance – PTS and PT-limits
  - Using FAVOR and leveraging analyses from PTS re-evaluation
  - Determine change in through-wall crack frequency as a function of shift in $RT_{NDT.}$
- Conduct a plant impact study of a select number of operating reactors
  - Smart sample of plants with applicable features, e.g., high fluence, high copper, etc.
  - Use working group's RG update recommendations and criteria developed above.
- Using the results of these analyses, determine Regulatory Guide implementation options.

Project Milestones

Milestone	WG t Target	OG Target
Develop Criteria for PT-limits		12/1/2019
Develop Criteria for PTS		12/1/2019
Conduct initial plant impact		1/14/2020
Develop and assess initial framework for revised regulatory guide	1/14/2020	
Public meeting with stakeholders	2/14/2020	
Decision point for continuation of RG development	3/1/2020	3/1/2020
Draft RG for internal review	4/30/2019	

List of Acronyms

- ART – adjusted reference temperature
- EMA – equivalent margins analysis
- ETC – embrittlement trend curve
- FAVOR – Fracture Analysis of Vessels, Oak Ridge (computer code)
- RG – regulatory guide
- RT_{NDT} - reference temperature, nil-ductility transition
- ΔRT_{NDT} - change in RT_{NDT} due to irradiation
- PSSP – PWR Supplemental Surveillance Program
- P-T Limits – pressure-temperature limits
- PTS – pressurized thermal shock
- TLR – technical letter report
- USE – upper shelf energy

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Potential Revision of *Regulatory Guide 1.99, Revision 2*

Tim Hardin
Technical Executive

Meeting of the ACRS

November 6, 2019
Rockville, MD

www.epri.com

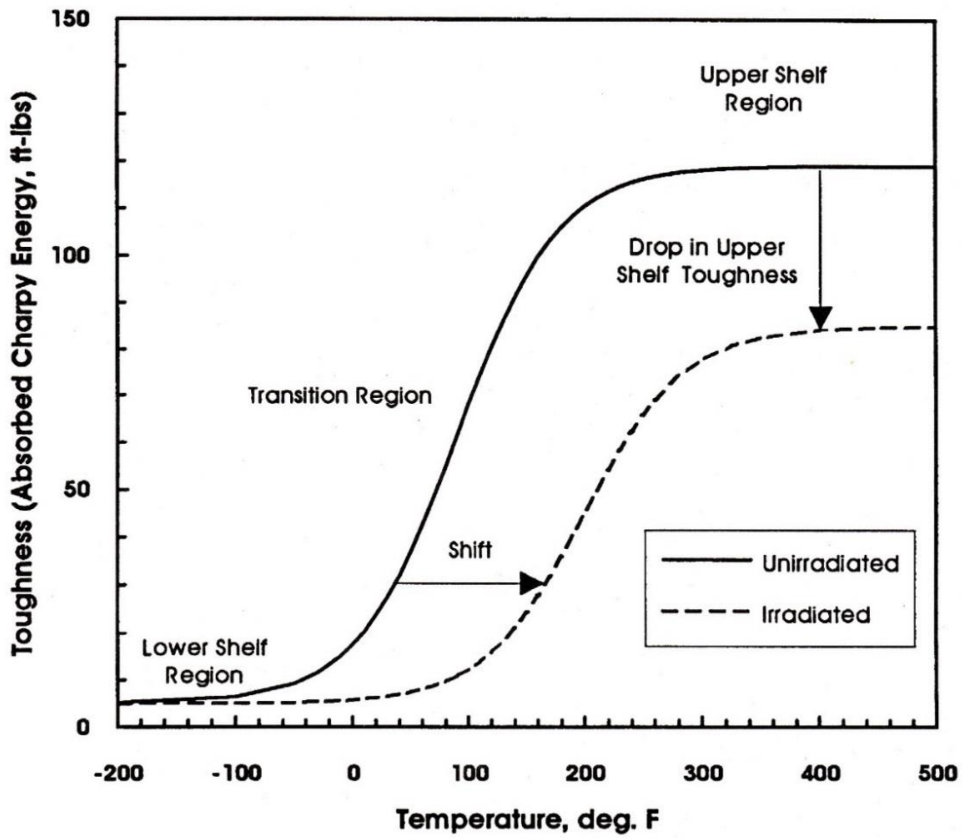
Contents

- Background
- Potential Revision of the Regulatory Guide 1.99, Revision 2 (RG1.99R2) Upper Shelf Energy (USE) Prediction Model
- Potential Revision of the RG1.99R2 ΔT_{41J} ($\Delta T_{30\ ft\text{-}lb}$) Prediction Model
  - Considerations for BWR and PWR Fleets
  - Recommended Alternative ΔT_{30} Prediction Model
  - Preliminary Assessment of Fleet Impact
- Conclusions and Recommendations

This presentation offers the professional opinions of EPRI staff *only* and does not represent an Industry position of the U.S. utilities

Background (1/2)

- In July 2019, NRC released "Assessment of the Continued Adequacy of Revision 2 of Regulatory Guide 1.99," Technical Letter Report TLR-RES/DE/CIB-2019-2 (hereafter, the TLR)
- EPRI provided review comments on the TLR at the August 22, 2019 meeting of the ACRS Subcommittee on Metallurgy & Reactor Fuels (ADAMS ML 19260E007)
- Since that meeting, EPRI has studied the potential impact that a revision of Regulatory Guide 1.99 may have on the fleet
- This presentation summarizes the results of that study and provides recommendations regarding implementation of a new RG



"Shift" refers to the change in Ductile-Brittle Transition Temperature (DBTT), as measured by Charpy ΔT_{30} (ΔT_{41J})

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Background (2/2)

- Principal conclusions from EPRI review of the NRC TLR
  - The conclusions of the TLR are succinct and their technical bases are thoroughly documented
  - The recommendations of the TLR are reasonably supported by the analyses presented
  - The data and analyses presented in the TLR support a ***phased implementation*** of any revision to RG1.99R2 to **minimize unnecessary burden on the operating fleet**

Potential Revision of the RG1.99R2 Upper Shelf Energy (USE) Prediction Model

USE Decrease Prediction Model

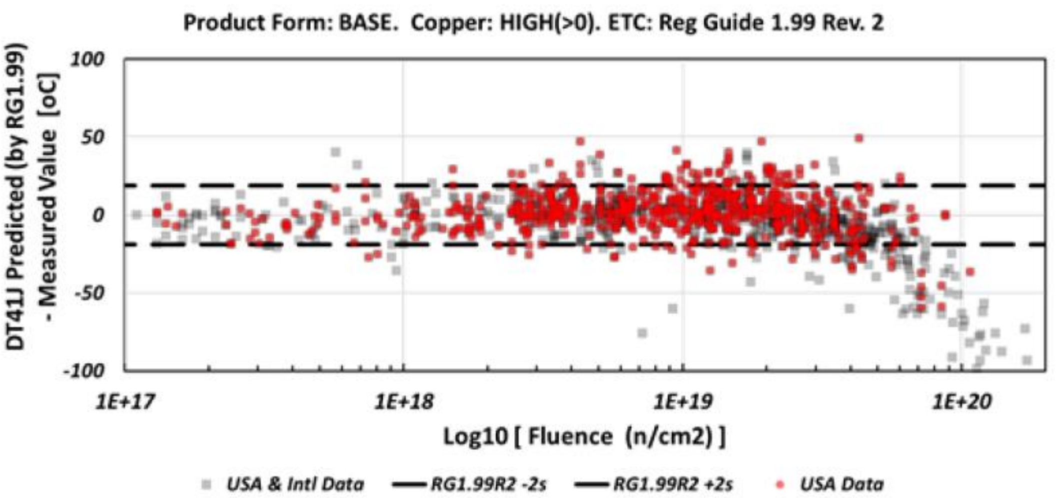
- In the August 22, 2019 Subcommittee Meeting, EPRI discussed a new USE prediction model developed by the Materials Reliability Program (MRP) in 2017 and published as MRP-414
  - *Materials Reliability Program: Prediction Model for the Decrease in Upper Shelf Energy of Reactor Vessel Steel Due to Neutron Embrittlement (MRP-414)*. EPRI, Palo Alto, CA: 2017.
- This model achieves a 2σ bound of the USE decrease data
- An evaluation of the impact of the MRP-414 model on the PWR fleet found:
  - The total number of plants which have materials predicted to fall below 68 J at 80 years is the same, when either the RG1.99R2 or the MRP-414 model is used
- Also, it is noted that no material which has been predicted to fall below 68 J has been unacceptable when evaluated using an Equivalent Margins Analysis (EMA) per RG1.161 and ASME XI Appendix K
  - The 68 J minimum USE criterion in 10CFR50, Appendix G is conservative

Changing the USE prediction model in RG1.99R2 would result in negligible safety benefit but would cause a significant reanalysis burden for the fleet

Potential Revision of the RG1.99R2 ΔT_{41J} ($\Delta T_{30\ ft\text{-}lb}$) Prediction Model

ΔT_{41J} Prediction Model

- The NRC TLR concluded
  - "…the estimates of embrittlement provided by RG1.99 appear to become non-conservative at fluence levels approaching 3 to 6 x 10^{19} n/cm^2 (E > 1 MeV)" and
  - "…it is evident that a fluence limit should be established to indicate when RG1.99 ceases to adequately predict ΔT_{41J} for regulatory purposes."
- The NRC TLR does not specify a fluence limit, but the implication is somewhere 3 – 6 x 10^{19} n/cm^2 (E > 1 MeV)
- Because RG1.99R2 is used for embrittlement predictions to show compliance with 10CFR50, Appendix G, the appropriate metric for assessing the need for a change to the RG1.99R2 ΔT_{41J} prediction model is the RPV **1/4T fluence**, since that is the fluence upon which operating limits are based per ASME XI App. G



Considerations for the BWR Fleet

- Based on the TLR's assessment that the predictions of RG1.99R2 ΔT_{41J} prediction model are non-conservative at fluences ~ 3 – 6 x 10^{19} n/cm^2 (E > 1 MeV), we note:
  - From BWRVIP-321, *Plan for Extension of the BWR Integrated Surveillance Program (ISP) Through the Second License Renewal (SLR)*:
    - "…most plants have projected target 1/4T SLR fluences that fall within a similar range, between 1 x 10^{18} and 5 x 10^{18} n/cm^2…while several plants are projected to have much higher fluence, on the order of 6 to 9 x 10^{18} n/cm^2"
  - The 80 year fluences for the BWR fleet are well below the range at which RG1.99R2 becomes non-conservative

The BWR fleet can safely use the existing RG1.99R2 ΔT_{41J} prediction model through an 80 year life

Considerations for the PWR Fleet

- For PWRs, 1/4T fluence is higher than for BWRs and many vessels will exceed the ~ 3 – 6 x 10^{19} n/cm^2 (E > 1 MeV) threshold
- For a particular vessel, a new embrittlement prediction model may increase shift for some materials, but decrease shift for other materials
- To assess the potential impact on the Adjusted Reference Temperatures (ART) of each vessel material, it is necessary to identify what new prediction model will be used
  - Probable candidates are assessed in the next slide

Comparison of Potential Alternative ΔT_{30} Trend Curve Prediction Formulae

ID	ASTM E900-15	EONY
Year	2015	2006
Fit to	LWR surveillance data from 13 countries (USA, Japan, France, Germany, S. Korea, Belgium, …)	LWR surveillance data from the USA
# of ΔT_{30} Data	1,878	855
Development	Result of ASTM consensus process, 2010-2015	Result of NRC contractor effort, 1998-2006
Status	Adopted as an ASTM Standard Guide	Adopted in 10 CFR 50.61a Applied to one plant (Palisades) to date

ASTM E900-15 is the Preferred Alternative ΔT_{30} Trend Curve Prediction Formula

Assessment of Fleet Impact of E900-15 ΔT_{30} Trend Curve

Methodology

- **Differences between alternative (E900-15) and RG1.99R2 ΔT_{30} predictions quantify the impact**

$$\text{Difference} = \Delta T_{30}^{E900-15} - \Delta T_{30}^{\text{RG1.99R2}}$$

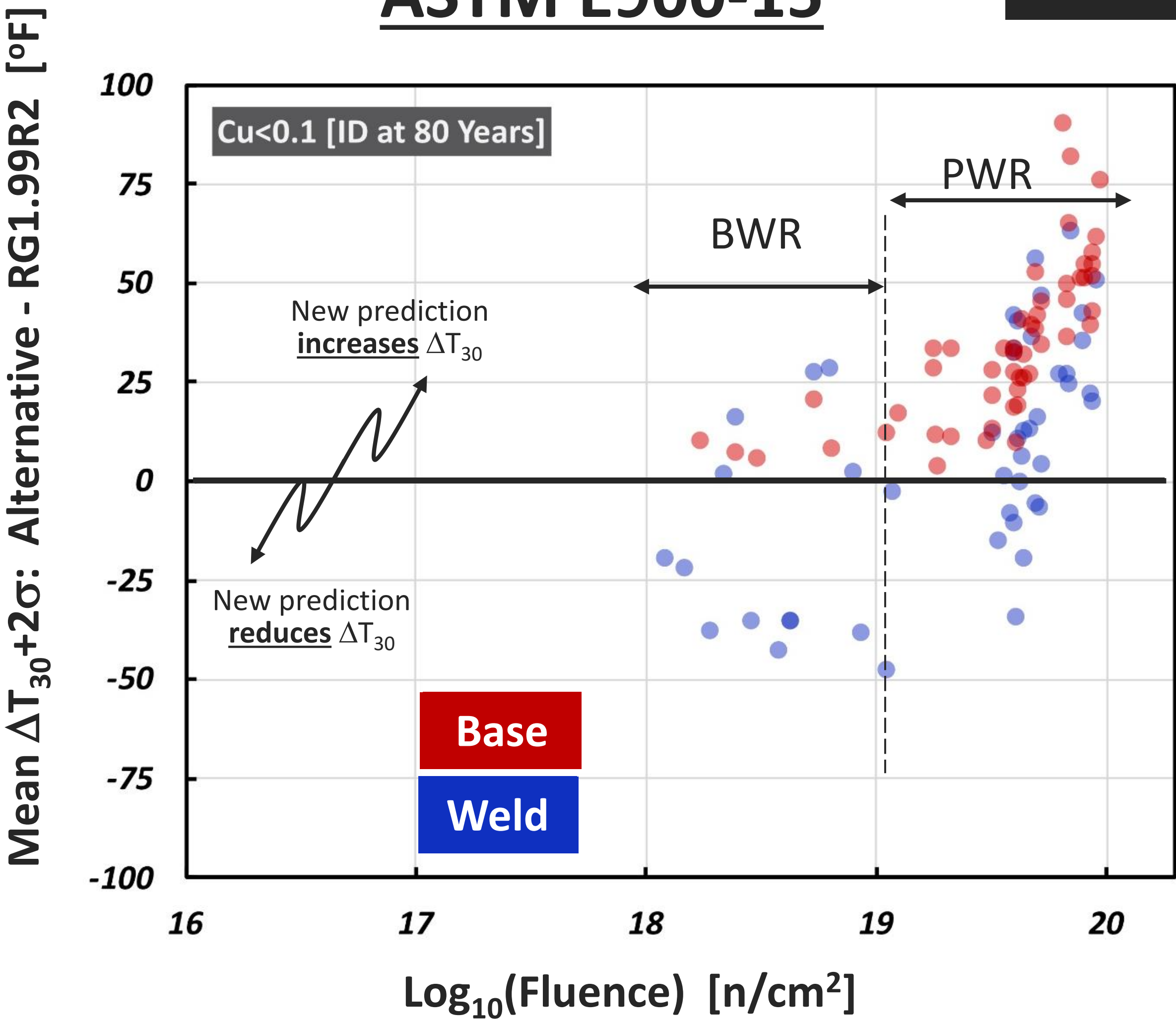
  - Impact
    - Positive difference: increases shift / possible impact on operations
    - Negative difference: decreases shift / provides relief
  - Values compared
    - Mean + 2σ predictions at Inside diameter (ID)
  - Evaluated Low copper (Cu) steels and High Cu steels separately
- **Data used / assumptions**
  - Evaluated projected fluence values at 80 years
  - Capacity factor: 90%
  - The evaluation was conducted using available US surveillance data, not all RPV materials

Comparison of ASTM E900-15 to RG1.99R2 Trend Curve

Low-Cu Steels

Time	Fleet @ 80 years
Copper	Low (<0.1 wt%)
Location	Inner Diameter
Prediction	Mean ΔT_{30} +2σ

ASTM E900-15

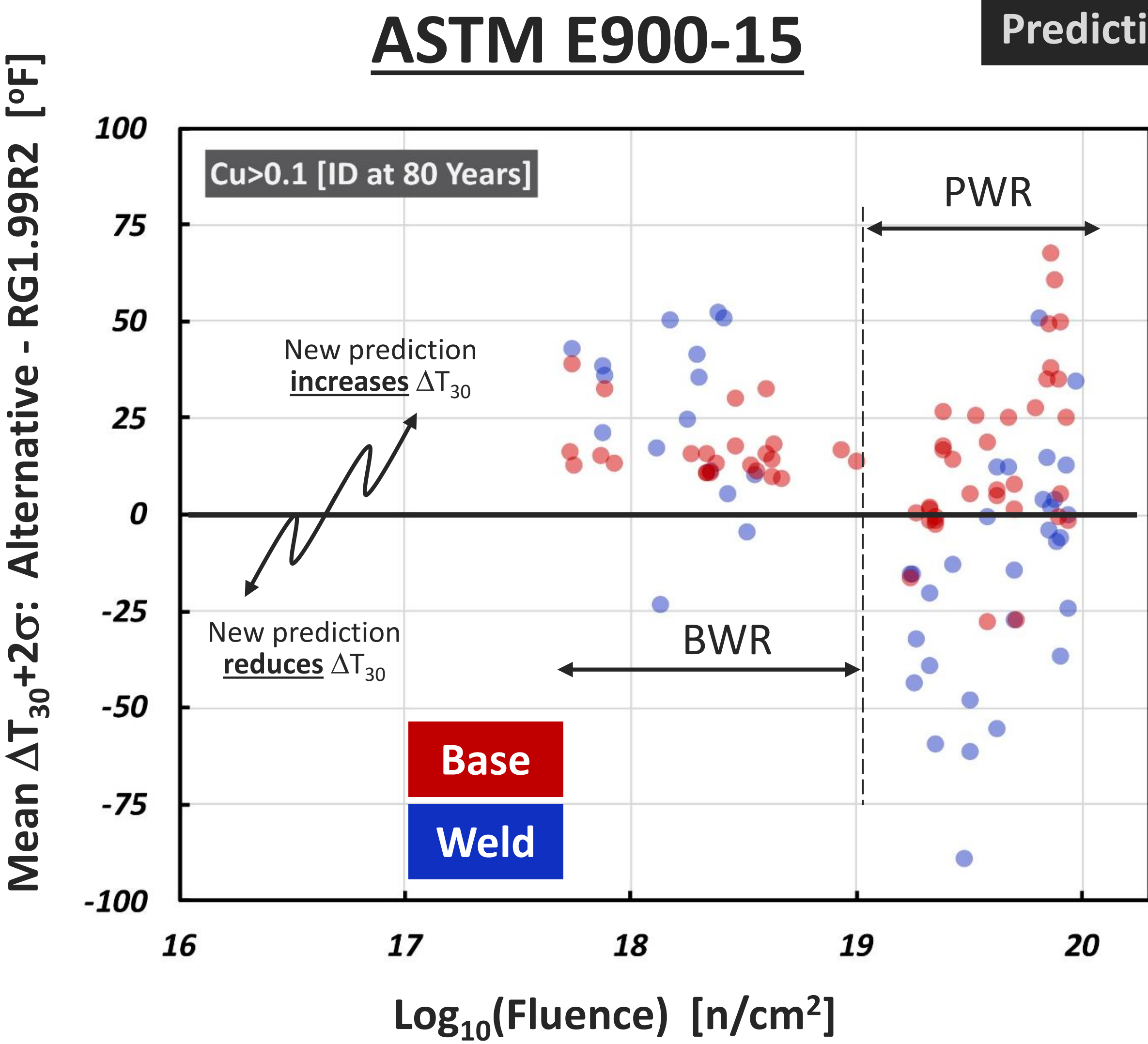


ELECTRIC POWER RESEARCH INSTITUTE

Comparison of ASTM E900-15 to RG1.99R2 Trend Curve

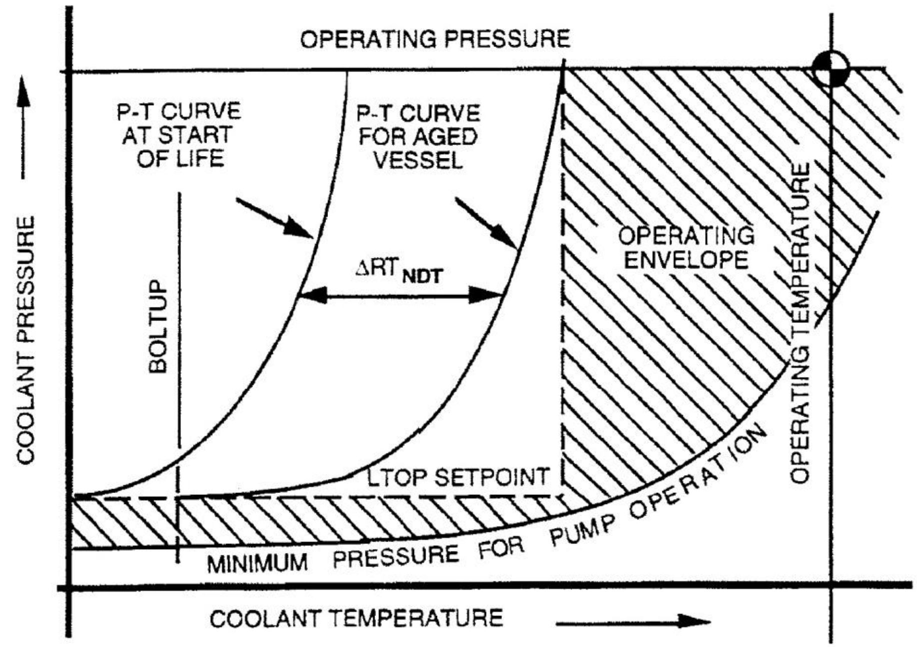
High-Cu Steels

Time	Fleet @ 80 years
Copper	High (>0.1 wt%)
Location	Inner Diameter
Prediction	Mean ΔT_{30} +2σ



Impact of Adopting ASTM E900-15 Shift Prediction Model (1/2)

- Changing from the RG1.99R2 ΔT_{41J} model to ASTM E900-15 will increase predicted embrittlement shift for some materials, and decrease it for others
  - <u>In general</u>, base metals (plates and forgings) will see increases; welds will see both increases and decreases.
- Estimating the net impact of these trends on the licensing basis (e.g., the P-T curves) for any particular vessel requires a vessel-specific evaluation
  - Depending on the direction and magnitude of the shift change for each vessel material, there may or may not be an impact on the plant operating limits (P-T curves).



  - Whether or not the shift changes would require revision of the plant P-T curves is unknown until the specific ART values are calculated for all materials in that vessel and compared to the ART values used as the basis for the plant's existing P-T limits

Impact of Adopting ASTM E900-15 Shift Prediction Model (2/2)

- Vessel-specific evaluations until are not possible until NRC provides guidance on:
  - What prediction model should be used
  - How surveillance data is to be used / credited
    - Plant-specific data, “sister plant” data, etc.
- Performing the vessel specific evaluation would involve significant burden that has no safety benefit if the plant’s 1/4T fluence is < 3 - 6 x 10^{19} (e.g., the fluence level below which the TLR identifies no safety concern for the current RG1.99R2 prediction model)

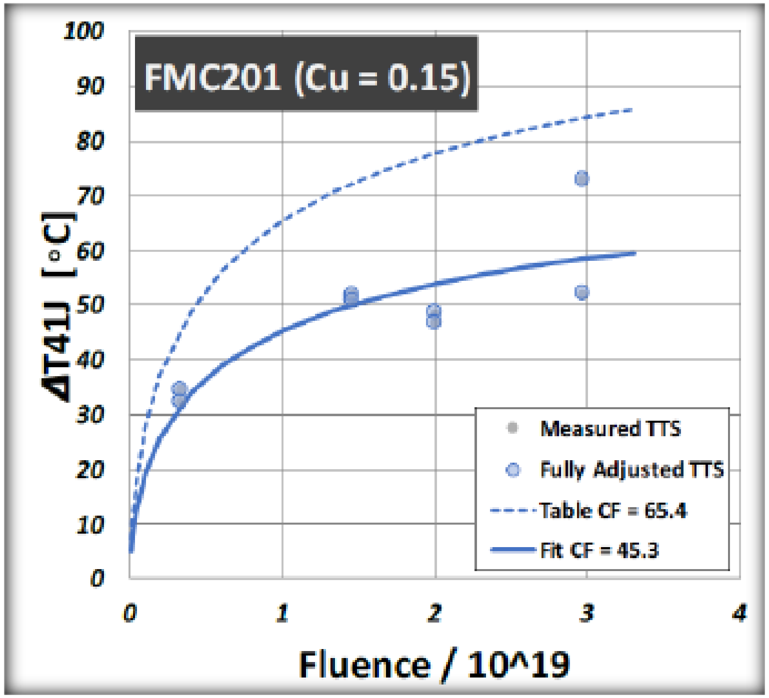


Figure from TLR-RES/DE/CIB-2019-2 illustrating consideration of surveillance data

A 1/4T fluence metric is recommended for screening plants that need (or do not need) to use a new RG1.99 ΔT_{41J} prediction model

Conclusions and Recommendations

- Changing the USE prediction model in RG1.99 would result in negligible safety benefit but would cause a significant reanalysis burden on the fleet
- ASTM E900-15 is the preferred alternative ΔT_{41J} prediction formula
- Because RG1.99 is used for embrittlement predictions performed to show compliance with 10CFR50, Appendix G, the appropriate metric for assessing the need for plants to adopt a new ΔT_{41J} prediction model is the RPV 1/4T fluence, since that is the fluence upon which operating limits are based per ASME XI Appendix G
  - BWRs do not reach the threshold of concern through 80 years of operation and can be exempted from the burden of adopting a new ΔT_{41J} shift prediction model
  - PWR adoption of a new shift prediction model would appropriately be based on a 1/4T fluence metric
- Because embrittlement prediction models have significant impact on the RPV operating envelop, it will be helpful to plants considering SLR for the regulator to identify the shift model that will be adopted in RG1.99R3, and guidance for consideration of surveillance data

Together…Shaping the Future of Electricity

Brunswick Steam Electric Plant Units 1 and 2 License Amendment Request

Application of Advanced Framatome Methodologies

DUKE ENERGY® PROGRESS

BSEP Station Overview and

Advanced Framatome Methods LAR Overview

Mark DeWire – BSEP Assistant OPS Manager - Shift

BSEP Station Overview

- General Electric BWR-4, Mark I Containment
- Began commercial operation in 1975 (Unit 2) and 1976 (Unit 1), OLTP 2436 MWt
- EPU (120% OLTP) 2923 MWt fully implemented in 2004 (Unit 1) and 2005 (Unit 2)
- 24 month operating cycle
- Transitioned to Framatome Fuel in 2008 (U1) and 2009 (U2)
- Currently Full Core Framatome ATRIUM 10XM Fuel
  - 8 ATRIUM 11 Lead Test Assemblies installed on Unit 2 in 2015
- Licensed for Increased Core Flow (ICF)
  (i.e., 110% Core Flow at reduced power, 104.5% Core Flow at CLTP 2923 MWt)
- Licensed for Maximum Extended Load Line Limit Analysis Plus (MELLLA+)
  (i.e., 85% Core Flow at CLTP 2923 MWt)

LAR Overview

- Technical Specification (TS) 5.6.5.b lists the analytical methods used to determine core operating limits.
- This license amendment request (LAR) revises TS 5.6.5.b to allow application of Advanced Framatome Methodologies for determining core operating limits in support of loading Framatome fuel type ATRIUM 11.
- Duke Energy is pursuing the ATRIUM 11 fuel type due to the improved fuel cycle economics and safety margins.
  - 11x11 array reduces fuel duty ~19%: LHGR margin
  - Improved debris protection features (fuel failure risk reduction)
  - Improved channel performance
  - Improved fuel cycle economics

LAR Overview (continued)

- The following Methodologies will be removed from TS 5.6.5.b as they will no longer be applicable with the addition of the Advanced Framatome Methods.
  - XN-NF-84-105(P)(A) Volume 1, XCOBRA-T: A Computer Code for BWR Transient Thermal-Hydraulic Core Analysis
  - ANF-913(P)(A) Volume 1, COTRANSA2: A Computer Program for Boiling Water Reactor Transient Analyses
  - NEDC-33075P-A, GE Hitachi Boiling Water Reactor, Detect and Suppress Solution - Confirmation Density, Revision 8, November 2013

LAR Overview (continued)

- The Advanced Methodologies that will be added to TS 5.6.5.b are listed below.
  - ANP-10300P-A, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios, Rev. 1, January 2018
  - ANP-3703P, BEO-III Analysis Methodology for Brunswick Using RAMONA5-FA, Rev. 0, August 2018
  - DPC-NE-1009-P, Brunswick Nuclear Plant Implementation of Best-estimate Enhanced Option-III, Rev. 0, September 2018
  - BAW-10247P-A, Supplement 2P-A, Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors Supplement 2: Mechanical Methods, Rev. 0, June 2018
  - ANP-10340P-A, Incorporation of Chromia-Doped Fuel Properties in AREVA Approved Methods, Rev. 0, May 2018
  - ANP-10335P-A, ACE/ATRIUM 11 Critical Power Correlation, Rev. 0, May 2018
  - ANP-10333P-A, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Control Rod Drop Accident (CRDA), Rev. 0, March 2018
  - ANP-10332P-A, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Loss of Coolant Accident Scenarios, Rev. 0, March 2019

Advanced Framatome Methods LAR

Supporting Information and Schedule Milestones

Mike Blom – Director – Fuel Management and Design

LAR Supporting Information

- The following documents, included in the LAR, demonstrate acceptability of the LAR supporting operation of the new ATRIUM 11 fuel type in the currently approved operating domain (i.e., including EPU and MELLLA+).
  - ANP-3705P, Applicability of Framatome BWR Methods to Brunswick with ATRIUM 11 Fuel
  - ANP-3686P, Mechanical Design Report for Brunswick ATRIUM 11 Fuel Assemblies
  - ANP-3643P, Brunswick Unit 1 Thermal-Hydraulic Design Report for ATRIUM 11 Fuel Assemblies
  - ANP-3644P, Brunswick Unit 2 Thermal-Hydraulic Design Report for ATRIUM 11 Fuel Assemblies
  - ANP-3668P, ATRIUM 11 Fuel Rod Thermal-Mechanical Evaluation for Brunswick LAR
  - ANP-3661P, Brunswick ATRIUM 11 Equilibrium Cycle Fuel Cycle Design
  - ANP-3667P, Brunswick Unit 1 ATRIUM 11 Equilibrium Cycle Nuclear Fuel Design Report
  - ANP-3702P, Brunswick ATRIUM 11 Transient Demonstration

LAR Supporting Information (continued)

- ANP-3674P, Brunswick Units 1 and 2 LOCA Analysis for ATRIUM 11 Fuel
- ANP-3694P, ATWS-I Analysis Methodology for Brunswick Using RAMONA5-FA
- ANP-3703P, BEO-III Analysis Methodology for Brunswick Using RAMONA5-FA
- DPC-NE-1009-P, Brunswick Nuclear Plant Implementation of Best-estimate Enhanced Option-III
- ANP-3714P, Brunswick ATRIUM 11 Control Rod Drop Accident Analyses with the AURORA-B CRDA Methodology

Cycle Specific Reports

- Duke Energy provided the B1C23 reload reports outlined in the table below to the NRC for information during this review.

Report
B1C23 Fuel Cycle Design Report
B1C23 Nuclear Fuel Bundle Design Report
B1C23 Safety Limit MCPR Report
B1C23 Fuel Rod Design Report
B1C23 Reload Safety Analysis Report

AURORA-B LOCA

- The Final Safety Evaluation (SE) for Topical Report (TR) ANP-10332P AURORA-B LOCA had not been issued at the time of LAR submittal.
- The Draft SE along with ANP-10332P were referenced for the initial LAR submittal.
- All the limitations and conditions presented in the Draft SE were addressed in the initial LAR submittal.
- Following issuance of the Final SE for ANP-10332P, the LAR was supplemented with reference to the approved AURORA-B LOCA TR (i.e., ANP-10332P-A) and changes in limitations and conditions were addressed.

BEO-III w/ CDA

- With the addition of these methodologies, BSEP is transitioning from the Detect and Suppress Solution – Confirmation Density (DSS-CD) stability methodology to the Best Estimate Enhanced Option-III with Confirmation Density Algorithm (BEO-III w/CDA) stability methodology.
- As with DSS-CD, the CDA will remain the licensing basis trip, and identical Oscillation Power Range Monitor (OPRM) licensing basis setpoints will be used for BEO-III w/CDA thereby minimizing the impact to BSEP.
- The LAR provided a demonstration of the implementation of BEO-III with CDA with sample Brunswick ATRIUM 11 results from the currently approved operating domain.

RAMONA5-FA ATWS-I

- In addition to the methodology changes, with the transition from ATRIUM 10XM fuel to ATRIUM 11 fuel, BSEP will transition to RAMONA5-FA for the licensing basis Anticipated Transient Without Scram with Instability (ATWS-I) analysis.
- The current ATWS-I licensing basis analysis is the TRACG ATWS-I evaluation performed with ATRIUM 10XM fuel for MELLLA+ which was approved for BSEP in 2018.
- The LAR documents ATWS-I licensing basis analysis for Brunswick with ATRIUM 11 fuel and the currently approved operating domain.
- The Brunswick specific methodology is identical to ANP-10346P, ATWS-I Analysis Methodology for BWRs Using RAMONA5-FA, which is pending final approval by the NRC for generic application.

LAR Schedule Milestones

October 2018	LAR submittal
December 2018	Duke / NRC schedule review to support February 2020 need date
February 2019	Audit - BEO-III Plant Specific Methodology
March 2019	Audit - All Methodology
March to October 2019	Implementation cycle reports submitted for information
June 2019	RAI Responses
July 2019	LOCA Supplement
October 2019	Additional License Condition for BEO-III w/CDA
November 2019	ACRS Sub-Committee and Full Committee
February 2020	LAR approval
March 2020	Implementation cycle startup

Questions

Additional Info

ATRIUM 11 Fuel Design and Methodology Information

- In accordance with the process described in ANF-89-98(P)(A) Revision 1 and Supplement 1, a summary of the evaluation of the ATRIUM 11 design against the NRC-approved generic design criteria was provided to the NRC during this review.
  - ANP-3653P, Fuel Design Evaluation for ATRIUM 11 BWR Reload Fuel
- A compendium of Framatome methodologies and design criteria, which are described in Topical Reports that the NRC has found acceptable for referencing in BWR licensing applications was provided to the NRC during this review.
  - ANP-2637P, “Boiling Water Reactor Licensing Methodology Compendium”

Methodology Application

Methodology	Application
ANP-10333P-A, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Control Rod Drop Accident (CRDA), Revision 0, March 2018	Attachment 17
ANP-10300P-A, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios, Revision 1, January 2018	Attachment 12
ANP-3703P, BEO-III Analysis Methodology for Brunswick Using RAMONA5-FA, Revision 0, August 2018	Attachment 15
DPC-NE-1009-P, Brunswick Nuclear Plant Implementation of Best-estimate Enhanced Option-III, Revision 0, September 2018	Attachment 16
BAW-10247P-A, Supplement 2P-A, Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors Supplement 2: Mechanical Methods, Revision 0, June 2018	Attachment 6
ANP-10340P-A, Incorporation of Chromia-Doped Fuel Properties in AREVA Approved Methods, Revision 0, May 2018	Attachment 9
ANP-10335P-A, ACE/ATRIUM 11 Critical Power Correlation, Revision 0, May 2018	Attachment 7, 8, 10, and 12
ANP-10332P-A, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Loss of Coolant Accident Scenarios, Revision 0, [DATE]	Attachment 13

LAR Attachment Numbers

Attachment Number	Attachment Name
5	ANP-3705P, Applicability of Framatome BWR Methods to Brunswick with ATRIUM 11 Fuel
6	ANP-3686P, Mechanical Design Report for Brunswick ATRIUM 11 Fuel Assemblies
7	ANP-3643P, Brunswick Unit 1 Thermal-Hydraulic Design Report for ATRIUM 11 Fuel Assemblies
8	ANP-3644P, Brunswick Unit 2 Thermal-Hydraulic Design Report for ATRIUM 11 Fuel Assemblies
9	ANP-3668P, ATRIUM 11 Fuel Rod Thermal-Mechanical Evaluation for Brunswick LAR
10	ANP-3661P, Brunswick ATRIUM 11 Equilibrium Cycle Fuel Cycle Design
11	ANP-3667P, Brunswick Unit 1 ATRIUM 11 Equilibrium Cycle Nuclear Fuel Design Report
12	ANP-3702P, Brunswick ATRIUM 11 Transient Demonstration
13	ANP-3674P, Brunswick Units 1 and 2 LOCA Analysis for ATRIUM 11 Fuel
14	ANP-3694P, ATWS-I Analysis Methodology for Brunswick Using RAMONA5-FA
15	ANP-3703P, BEO-III Analysis Methodology for Brunswick Using RAMONA5-FA
16	DPC-NE-1009-P, Brunswick Nuclear Plant Implementation of Best-estimate Enhanced Option-III
17	ANP-3714P, Brunswick ATRIUM 11 Control Rod Drop Accident Analyses with the AURORA-B CRDA Methodology

BSEP Unit 1 and Unit 2 Differences

- BSEP Unit 1 and Unit 2 are essential identical. The key differences in system configuration are in the core inlet region and the turbine bypass system.
  - Fuel Support Casting Central Orifice Diameter
    - Unit 1: 2.43”
    - Unit 2: 2.09”
  - Turbine Bypass System
    - Unit 1: 4 Valves
    - Unit 2: 10 Valves
- As a result of these minor differences, Unit 1 is more limiting with respect to long term stability and ATWS-I. Therefore, Unit 1 was the modeled plant for these methodology demonstrations.

Power Density Comparison for MELLLA+ Submittals

Plant	GGNS	PB	BFN	BSEP	NMP2	MNGP
EPU Thermal Power (MWth)	4408	3951	3952	2923	3988	2004
Licensed Core Flow (Mlb/hr)	112.5	102.5	102.5	77	108.5	57.6
MELLLA+ knee % power	80.6	78.8	77.6	77.6	77.6	82.5
MELLLA+ knee % flow	55	55	55	55	55	57.4
power/flow ratio at MELLLA+ knee	57.42	55.23	54.40	53.56	51.86	50.01
power density (kW/ft)	5.5	4.8	4.8	4.9	4.9	4
power density (kW/L)	62.3	58.4	58.4	59	59	48.3

Introduction

Brunswick Fuel Transition to Framatome ATRIUM-11 License Amendment Request

Presented to the ACRS
November 6, 2019

Andy Hon, *PE*
Project Manager
Division of Operation Reactor Licensing
Office of Nuclear Reactor Regulation

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Brunswick ATRIUM 11 Fuel License Amendment Background

- Current Framatome ATRIUM-XM10 fuel was approved to operate in MELLLA+ domain - Integrated analyses from GEH and Framatome in September 2018.
- LAR was submitted in October 2018 for the adopting advanced Framatome methods for ATRIUM 11 - Decision needed by February 2020 to support fuel loading in scheduled outage.
- First application of seven new Framatome analyses and one Duke Energy method for the new fuel design.
- Most of the new methodologies have been already approved generically as topical reports.
- Requested changes are mainly COLR references to the new Framatome methodologies in Chapter 5 of the Tech Specs.

NRC Staff Safety Evaluation

- Reviewed the L&Cs of approved generic topical reports are addressed by BSEP.
- Reviewed plant specific stability technical reports and identified the necessary license conditions for implementation and enforcement.
- Conducted two audits of safety analyses – February and March 2019.
- 32 RAIs – all accepted and satisfactorily responded by Duke Energy. License conditions were adopted for implementation.
- RES performed an ATWSi confirmatory study using TRACE code to model the new fuel performance at Brunswick.
- Prepared to make a decision on the request after finalizing SE to incorporate the ACRS comments to support the requested completion date.

NRC Staff Review Team

Office of Nuclear Reaction Regulation		
A. Smith (Lead)	J. Borromeo	C. Cheung
E. Dickson	A. Hon	R. Grover
J. Lehning	S. Krepel	D. Woodyatt
A. Wysocki (ORNL)		
Office of Nuclear Regulatory Research		
P. Yarsky (Lead)	A. Bielen	C. Gingrich
N. Hudson	S. Marshall	T. Zaki