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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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668TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

+ + + + +

OPEN SESSION

+ + + + +

WEDNESDAY

NOVEMBER 6, 2019

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ROCKVILLE, MARYLAND

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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.

1 COMMITTEE MEMBERS:

2 PETER RICCARDELLA, Chairman

3 MATTHEW W. SUNSERI, Vice Chairman

4 JOY L. REMPE, Member-at-Large

5 RONALD G. BALLINGER, Member

6 DENNIS BLEY, Member

7 CHARLES H. BROWN, JR. Member

8 VESNA B. DIMITRIJEVIC, Member

9 WALTER L. KIRCHNER, Member

10 JOSE MARCH-LEUBA, Member

11 DAVID PETTI, Member

12

13 DESIGNATED FEDERAL OFFICIAL:

14 CHRISTOPHER BROWN

15

16 ALSO PRESENT:

17 MIKE BLOOM, Duke Energy

18 JOSH BORROMEO, NRR

19 MARK DeWIRE, Duke Energy

20 STEVE EVANS, Duke Energy

21 TIM HARDIN, EPRI

22 ALLEN HISER, NRR

23 ANDY HON, NRR

24 RAJ IYENGAR, RES

25 MEENA KHANNA, NRR

1 ALSO PRESENT (CONTINUED) :

2

3 JOHN LEHNING, NRR

4 LOUISE LUND, RES

5 SCOTT MOORE, Executive Director, ACRS

6 JEFF POEHLER, RES

7 DOUG PRUITT, Framatome

8 MARY JANE ROSS-LEE, NRR

9 DAVID RUDLAND, NRR

10 ASHLEY SMITH, NRR

11 DAN TINKLER, Framatome

12 ROBERT TREGONING, RES

13 DAN WIDREVITZ, NRR

14 AARON WYSOCKI, ORNL

15 PETER YARSKY, RES*

16 STEPHEN YODERSMITH, Duke Energy

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25 *Present via telephone

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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

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1 opportunities to address the Committee, as required by
2 FACA.

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

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

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

20 We have received no written comments or
21 requests to make statements from members of the public
22 regarding today's meeting. There will be an
23 opportunity for public comments, as we have set aside
24 10 minutes in the agenda for comments from members of
25 the public attending or listening to our meetings.

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

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

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

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

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

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

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

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

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

7 And I think that it's been noted that the
8 current Reg Guide dates from 1988. Since that time,
9 there has been a large amount of test data on
10 irradiated reactor vessel materials which have been
11 obtained from test or surveillance materials. So,
12 with licensees planning to operate plants out to 60 or
13 80 years, it is important that guidance for assessing
14 embrittlement be adequate for the neutron fluence
15 levels that are projected for those plants. New
16 plants will use reactor vessel materials with
17 different chemistries than the operating fleet.

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

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

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

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

9 MR. POEHLER: Good afternoon.

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

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

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1 then, discuss the Reg Guide 1.99 working group charter
2 and activities. And then, we'll discuss the Reg Guide
3 1.99 oversight group charter and activities.

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

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

8 MEMBER KIRCHNER: Much better.

9 MEMBER BLEY: Much better.

10 MR. POEHLER: Okay. Great.

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

13 (Laughter.)

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

17 (Laughter.)

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

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

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

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

6 MR. WIDREVITZ: Not quite. I remember
7 Ghostbusters.

8 (Laughter.)

9 The curve itself, it contains a number of
10 aspects, one of which is an embrittlement trend curve
11 purporting to predict the shift in ductile-to-brittle
12 transition temperature of reactor vessel steels, which
13 we call RTndt. This curve was fit to what was done
14 177 data points, datums. There was a relative paucity
15 of data at higher fluences because the fleet was
16 relatively young. And there was a relative paucity of
17 data concerning low copper materials because the fleet
18 designs were relatively old.

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

25 It contains what we call the credibility

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

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

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

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

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

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

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

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

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

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

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

7 CHAIRMAN RICCARDELLA: Right.

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

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

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

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

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

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

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

6 CHAIRMAN RICCARDELLA: Well --

7 MR. WIDREVITZ: Well, they're off.

8 CHAIRMAN RICCARDELLA: They're wrong,
9 yeah --

10 MR. WIDREVITZ: Compared to the modern
11 dataset.

12 CHAIRMAN RICCARDELLA: Yes.

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

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

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

23 CHAIRMAN RICCARDELLA: Yes.

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

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1 CHAIRMAN RICCARDELLA: Yes.

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

4 CHAIRMAN RICCARDELLA: Yes.

5 MR. WIDREVITZ: -- is not an issue.

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

8 MR. WIDREVITZ: So, in terms of results,
9 our primary conclusions: non-conservative high
10 fluence results for base metals become prominent at
11 fluences above, we generally say 6 times 10 to the
12 19th neutrons per centimeter squared. And that's
13 where your mean of your results goes below 2 sigma,
14 the Reg Guide's 2 sigma. So, you would expect your
15 results, on average, to be too low there.

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

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

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

7 In terms of delta used results, the
8 assessment for delta used was based on the REAP
9 dataset, which is a collection of surveillance, plant
10 surveillance results merged with the actual material
11 properties in baseline. The dataset, again, included
12 domestic and international power reactor data, 1200
13 data points, considerably more than we had in the
14 '80s.

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

25 However, the concern is, if you have a

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

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

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

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1 focus.

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

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

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1 the reduction in margin for credible data.

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

10 Why we're concerned about that here is
11 high fluence and low copper data are not expected to
12 conform to the fluence shape function of Reg Guide
13 1.99.

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

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

19 MEMBER PETTI: And data specific for your
20 plant material.

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

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

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

3 MR. WIDREVITZ: No.

4 (Laughter.)

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

9 Sorry. Sorry, Jeff. Go back.

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

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

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

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

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

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

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

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

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

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

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

25 The upper shelf energy model in the

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

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

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

19 Yes?

20 CHAIRMAN RICCARDELLA: Excuse me, Jeff.

21 MR. POEHLER: Sure.

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

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

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1 CHAIRMAN RICCARDELLA: It's a parameter in
2 it?

3 MR. POEHLER: Yes.

4 CHAIRMAN RICCARDELLA: Great. Okay.

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

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

23 The next --

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

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

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

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

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

19 MEMBER KIRCHNER: No, I understand that,
20 right.

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

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

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1 curve without having a large uncertainty band, yes.

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

6 MEMBER KIRCHNER: Yes, yes.

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

9 MEMBER KIRCHNER: Right.

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

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

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

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

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1 thinking about.

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

6 MR. WIDREVITZ: For material, three or
7 four.

8 CHAIRMAN RICCARDELLA: Three or four
9 points per material?

10 MR. WIDREVITZ: Yes.

11 CHAIRMAN RICCARDELLA: So, that's why.

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

16 CHAIRMAN RICCARDELLA: Right.

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

19 CHAIRMAN RICCARDELLA: Aspect of it.
20 Okay.

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

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

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

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

13 CHAIRMAN RICCARDELLA: Yes, yes.

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

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

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

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

25 CHAIRMAN RICCARDELLA: I know, but you

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

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

8 CHAIRMAN RICCARDELLA: Okay. Thank you.

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

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

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

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

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

6 MR. HISER: Okay. Thanks, Jeff.

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

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

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

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1 the key things that we need to sort through.

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

8 Next slide.

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

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

16 The Reg Guide, as was mentioned
17 previously, was issued in 1988. So, the next gap
18 there takes us to 2019 with the research report. The
19 entire rest of the timeline is an equivalent 31 years.
20 The items that are on the top represent plants where
21 we think the fluence make exceed 6 times 10 to the
22 19th neutrons per centimeter squared. We've used that
23 sort of as a trigger point where, from the charts that
24 Dan showed, at least for plate materials we may be
25 getting a deviation that's too much. I think that's

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

3 So, in this case for Turkey Point Plant,
4 which you've heard the SLR, I guess the whole
5 Committee heard about the SLR application and our
6 review. We expect that their surface fluence for the
7 vessel will exceed 6 times 10 to the 19th somewhere in
8 2025. Turkey Point, the 1/4T fluence will exceed that
9 level in 2044.

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

13 (Laughter.)

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

16 CHAIRMAN RICCARDELLA: I know.

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

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

25 Surface fluence is important for PTS. At

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

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

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

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

13 MEMBER BALLINGER: They used a different
14 correlation.

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

17 CHAIRMAN RICCARDELLA: Ah, okay. Okay.

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

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

25 MR. HISER: Turkey Point would shift a

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1 bit.

2 MEMBER BALLINGER: A bit?

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

4 MEMBER BALLINGER: Maybe to now?

5 MR. HISER: Yes.

6 (Laughter.)

7 MEMBER BALLINGER: Yes.

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

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

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

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

20 CHAIRMAN RICCARDELLA: Okay.

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

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

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

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

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

20 Okay. Next slide.

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

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1 PTS and for P-T limits? We're looking at doing FAVOR
2 runs to try to assess through-wall crack frequency and
3 leveraging some of the analyses from the PTS
4 reevaluation. That was what was used to develop
5 50.61(a). As I mentioned, if you have a shift in the
6 RTndt, maybe you underestimate the shift. What's the
7 impact on through-wall crack frequency?

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

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

25 Next slide, Jeff.

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

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

15 And next slide.

16 MEMBER REMPE: I think you really mean
17 2020 on that day, right?

18 (Laughter.)

19 MR. HISER: Thank you.

20 MEMBER REMPE: Yes.

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

23 MR. HISER: Revisionist history.

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

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1 30th, 2020? The internal review, how long does that
2 take? In other words, when can we get surety, if you
3 want to use that word, on what's going to happen?

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

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

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

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

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1 gain some efficiency in the Reg Guide process.

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

5 MR. IYENGAR: Well --

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

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

11 (Laughter.)

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

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

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

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

3 CHAIRMAN RICCARDELLA: I guess speaking
4 for myself -- and this isn't for the Committee, just
5 my personal opinion -- and I understand we have to be
6 cautious not to put an undue burden. But to be in a
7 situation where we have a trend curve based on 177
8 points that was published in 1988, and now we have
9 1900 data points that show there is some inadequacy,
10 I mean, to not revise the Reg Guide just doesn't make
11 sense.

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

15 CHAIRMAN RICCARDELLA: Yes, yes.

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

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

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

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

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

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

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

15 MR. HISER: Yes, that's correct.

16 And I think that was the end of our
17 presentation.

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

25 MR. HISER: Now this will be using

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1 probabilistic fracture mechanics, the FAVOR code.

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

5 MEMBER KIRCHNER: I know, yes.

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

10 MEMBER KIRCHNER: Right.

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

13 MEMBER KIRCHNER: Right.

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

19 MEMBER KIRCHNER: Right, flaw
20 distribution. Right.

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

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

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

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

7 CHAIRMAN RICCARDELLA: Right, with the
8 code, yes.

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

14 CHAIRMAN RICCARDELLA: Right.

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

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

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

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

9 MEMBER KIRCHNER: Maybe we have some
10 additional input.

11 MR. TREGONING: This is Rob Tregoning from
12 Research.

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

18 (Laughter.)

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

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

7 CHAIRMAN RICCARDELLA: Okay. Thank you.

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

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

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

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

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

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

22 (Laughter.)

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

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

5 CHAIRMAN RICCARDELLA: Industry is going
6 to be talking.

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

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

17 MEMBER MARCH-LEUBA: Yes.

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

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

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

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

5 MR. HISER: Correct.

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

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

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

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

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

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

6 MR. WIDREVITZ: And I just wanted to just
7 provide a little bit of the new reactors perspective,
8 because, until very recently, that's the only thing I
9 was doing. And we are here in the presentation -- you
10 know, our primary concern is the operating fleet. It
11 exists. It's real. They're moving these very high
12 fluence zones. As a new reactor person, Reg Guide
13 1.99 gives me very, very inaccurate predictions, to
14 the point that I really don't know from the Reg Guide
15 what's happening because the Reg Guide was concerned
16 with a different body of chemistries.

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

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

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

7 CHAIRMAN RICCARDELLA: Right.

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

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

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

24 CHAIRMAN RICCARDELLA: Okay.

25 MS. KHANNA: So, Meena Khanna.

1 Go ahead. Do you want to say your name?

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

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

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

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

24 MR. HARDIN: Good afternoon, everyone.

25 My name is Tim Hardin. I'm with the

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

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

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

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

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

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

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

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

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

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

12 Now, on the shift prediction model, we
13 note that the staff, as we heard -- and I have quoted
14 some lines out of the TLR here -- that the non-
15 conservatism of the Reg Guide starts in the area from
16 3 to 6 times 10 to the 19th. It seems that the
17 emphasis today has been on 6 times 10 to the 19th,
18 which we would understand and agree with.

19 And because the Reg Guide is used for
20 embrittlement predictions to show compliance with
21 10 CFR 50, Appendix G, then the appropriate metric to
22 look at in terms of deciding who is affected, and who
23 needs to implement a potential change, would be the
24 1/4T fluence for the vessel, because that's the
25 fluence that is used in generating pressure-

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

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

10 Most of the plants, the BWRs, have 1/4T
11 fluence, and the range is about 1 to 5 times 10 to the
12 18th. And some of the higher fluence BWRs have
13 fluences as high as 9 times 10 to the 18th. But
14 that's substantially below the fluence at which the
15 Reg Guide starts becoming non-conservative at 3 to 6
16 times 10 to the 19th. So, we do think that the BWR
17 fleet could be safety exempted from any change, and
18 they could continue to use the current Reg Guide shift
19 prediction model through the 80-year life.

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

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

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

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

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1 Reg Guide.

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

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

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

18 And again, this is the mean shift plus 2
19 sigma. And from 18 to 19 is the BWRs, and higher than
20 19 is the PWRs. This is the low copper. For the high
21 copper --

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

24 MR. HARDIN: This is projected --

25 CHAIRMAN RICCARDELLA: Projected.

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1 MR. HARDIN: -- fluences at 80 years.

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

4 MR. HARDIN: Yes.

5 CHAIRMAN RICCARDELLA: Okay.

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

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

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

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

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

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

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

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

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

13 MEMBER MARCH-LEUBA: Yes, I have one.

14 MR. HARDIN: Yes, sir?

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

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

25 MEMBER MARCH-LEUBA: So, the burden is on

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1 the paperwork and --

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

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

12 MR. HARDIN: Yes.

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

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

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

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

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

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

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

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

17 CHAIRMAN RICCARDELLA: The paperwork
18 burden is about the same.

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

21 CHAIRMAN RICCARDELLA: Yes.

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

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

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1 forward?

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

4 MEMBER BALLINGER: Not true?

5 MR. HARDIN: Well, to withdraw a capsule?

6 CHAIRMAN RICCARDELLA: Yes, sir.

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

10 MEMBER BALLINGER: Okay.

11 CHAIRMAN RICCARDELLA: Yes, yes, yes.

12 MEMBER BALLINGER: So, that would be a
13 burden?

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

18 MR. RUDLAND: This is Dave Rudland.

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

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

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1 everybody have to do the new P-T curve?

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

6 MEMBER MARCH-LEUBA: Yes.

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

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

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

17 MEMBER MARCH-LEUBA: Yes.

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

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

22 MEMBER BALLINGER: 10 CFR 50, Appendix
23 G --

24 CHAIRMAN RICCARDELLA: Huh

25 MEMBER BALLINGER: Appendix G is.

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

3 MEMBER BALLINGER: Yes.

4 CHAIRMAN RICCARDELLA: Oh, okay.

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

10 MR. HISER: Yes, this is Allen Hiser.

11 And that's what was done in the early '90s
12 with the PTS rule, was that the procedure in Reg Guide
13 1.99, Rev 2, was put into the rule. Now the question
14 about -- Reg Guides are guidance documents. They're
15 not regulation. Reg Guide 1.99, Rev 2, was actually
16 implemented using a Generic Letter that asked plants,
17 how will you predict embrittlement? Will you use Reg
18 Guide 1.99, Rev 2, or will you use some other
19 approach? Virtually I think everybody at that point
20 used Reg Guide 1.99, Rev 2. There have, subsequently,
21 been plants that have used, let's see, the master
22 curve approach, and they've used -- no, not .61(a).
23 I think some of the plants have developed their own
24 curves, like the BMW (sic) Owners Group developed
25 curves that were used.

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

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

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

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

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

23 (No response.)

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

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

3 (No response.)

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

6 You can close the line.

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

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

13 CHAIRMAN RICCARDELLA: Yes.

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

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

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

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

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

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

16 MEMBER BALLINGER: If you choose 6 times
17 10 to the 19th.

18 MEMBER BLEY: Yes.

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

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

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

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

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

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

8 MEMBER KIRCHNER: Right.

9 MEMBER BALLINGER: Yes.

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

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

16 CHAIRMAN RICCARDELLA: Yes.

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

20 CHAIRMAN RICCARDELLA: At the inside
21 surface Turkey Point hits 6 times 10 to the 19th at
22 2025, which is essentially five years from now, and at
23 1/4T, it hits it at 2044.

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

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

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

6 MEMBER BALLINGER: That's for PTS.

7 CHAIRMAN RICCARDELLA: No. No, no, no.

8 MEMBER BALLINGER: No?

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

12 MEMBER BALLINGER: Okay.

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

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

20 MR. HISER: This is Allen Hiser.

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

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

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

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1 CHAIRMAN RICCARDELLA: It's quarter inch.

2 (Laughter.)

3 MEMBER BALLINGER: It's quarter inch, yes.

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

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

13 MS. KHANNA: It's the ID.

14 MR. HISER: Well, at the --

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

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

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

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1 attenuation?

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

5 MEMBER KIRCHNER: Okay.

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

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

13 MEMBER KIRCHNER: Yes.

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

20 MR. HISER: That is correct. The surface
21 one is more applicable to PTS calculations, in
22 accordance with 50.61. The 1/4T is for Appendix G,
23 10 CFR Part 50, for pressure-temperature limits.

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

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1 1/4T flaw in Section 3.

2 (Laughter.)

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

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

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

19 CHAIRMAN RICCARDELLA: Because you're
20 using that 2 sigma. As I understand it, the 6 times
21 10 to the 19th is where the mean curve --

22 MR. RUDLAND: Goes beyond 2 sigma.

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

25 MR. RUDLAND: And the 3 curve is just

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

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

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

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

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

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

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

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

24 MEMBER MARCH-LEUBA: No?

25 CHAIRMAN RICCARDELLA: No. All right.

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

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

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

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

8 CHAIRMAN RICCARDELLA: Recess while we
9 change speakers.

10 (Whereupon, the foregoing matter went off
11 the record at 2:31 p.m. and went back on the record at
12 2:40 p.m.)

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

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

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

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

6 Go for it, Andy.

7 MS. ROSS-LEE: So, thank you.

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

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

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

20 MR. HON: Thank you, M.J.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

19 So, if we can find the slides? Perfect.

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

22 MR. DeWIRE: All right. Good afternoon.

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

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1 I'm here to give you just a brief overview
2 of the Brunswick station. We are a General Electric
3 BWR-4 with Mark I containment. Began commercial ops
4 in 1975-1976 for Unit 2 and Unit 1 with an original
5 license of 2436-megawatt thermal. Completed extended
6 power uprate which brought us up to 2923 megawatts in
7 the mid-2000s. And we're currently on a 24-month
8 operating cycle. And as mentioned, we are on Atrium
9 10XM fuel with eight lead assemblies of the Atrium 11.
10 We did transition over to Framatome fuel in 2008-2009
11 for Unit 1 and Unit 2.

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

16 The purpose of this is to do a Tech Spec
17 update to Section 565(b), which has our analytical
18 methods. We're going to be revising that section to
19 allowing Framatome methodologies to be used for Atrium
20 11 fuel. And we're pursuing the Atrium 11 fuel due to
21 improved fuel cycles. The 11x11 array reduces the
22 fuel duty by approximately 19 percent. It has
23 improved channel performance, improved fuel cycle
24 economics, and near and dear to me is the improved
25 debris protection features with BWR fuel.

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

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

11 MR. BLOOM: Good afternoon, everybody.

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

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

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

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

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

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

7 MR. BLOOM: Yes.

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

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

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

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

24 Those are the only changes.

25 MEMBER MARCH-LEUBA: Thank you.

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1 MR. BLOOM: Okay. I've move on to slide
2 10. So, on slide 10 is a list of some Brunswick Unit
3 1, Cycle 23, cycle-specific documents for just in the
4 reload design. These were provided. They are not
5 part of the LAR, but were provided as supplemental
6 information for the NRC to review, so they could see
7 how the methods were applied to an actual reload and
8 be able to do some comparisons between the results
9 from the cycle that was in the methodologies to the
10 actual cycle application.

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

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

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1 schedule.

2 On slide 12 is a discussion on our
3 stability method for both units. Currently, we use
4 the detect-and-suppress solution confirmation density,
5 otherwise known as DSS-CD. As we transition to Atrium
6 11 fuel for this upcoming outage, we will be
7 transitioning to the Framatome best estimate option 3,
8 with a confirmation density algorithm.

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

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

18 So, 13, we'll talk just a minute about
19 ATWS-I. So, this is a fuel-type-dependent analysis.
20 So, right now, for the resident fuel, which is Atrium
21 10XM, it's a TRACG-based analysis. As we introduce
22 Atrium 11, we'll be moving to the RAMONA5 Framatome-
23 based methodology for that.

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

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

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

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

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

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

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

25 MEMBER MARCH-LEUBA: I must say that, for

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

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

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

9 MR. BLOOM: Thank you.

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

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

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

18 (No response.)

19 Any members of the public want to present
20 a question?

21 (No response.)

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

24 Is the open line open right now?

25 Questions and comments, yes, sorry.

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1 Comments?

2 (No response.)

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

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

7 (No response.)

8 So, can you hit the gavel, Pete?

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

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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”

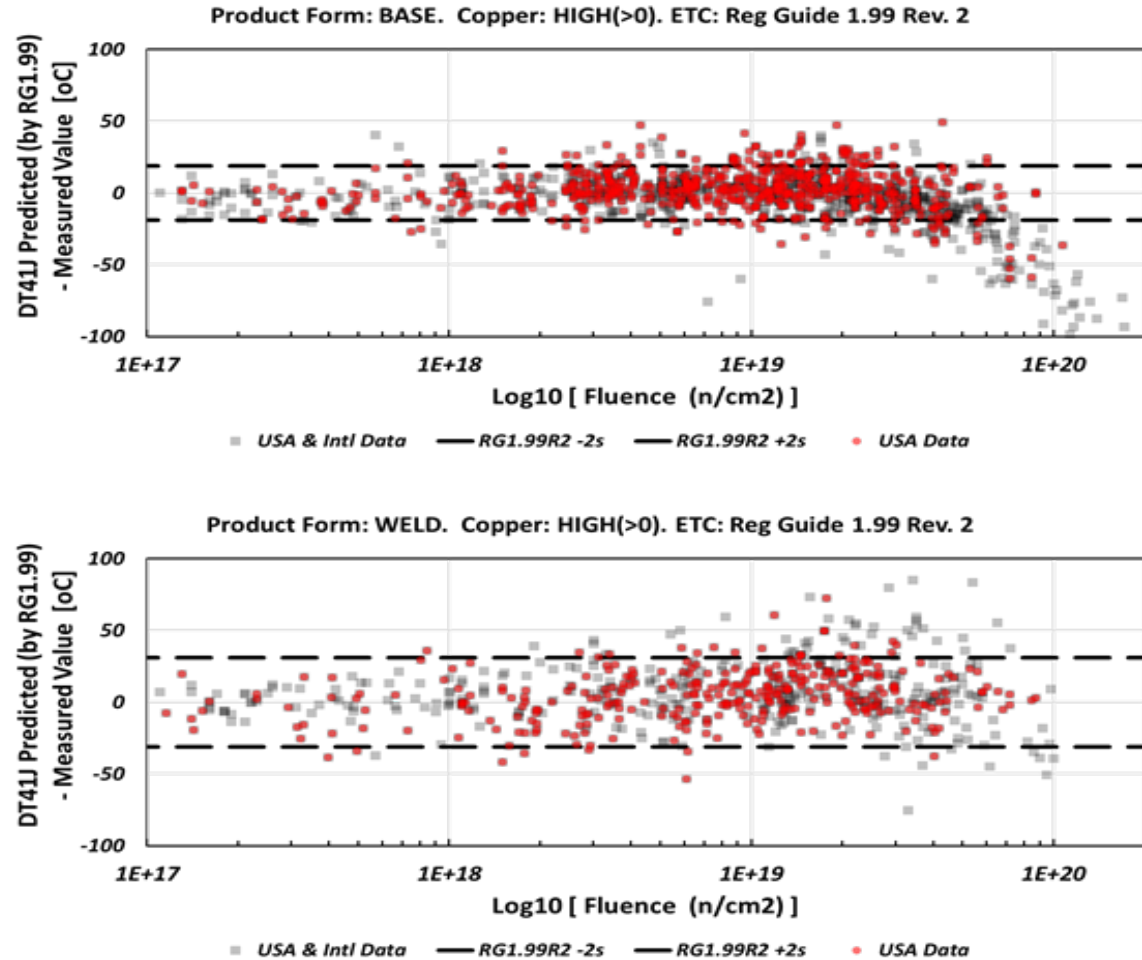
- Rev. 2 issued May, 1988.
- RT_{NDT} curves fit to 177 datum. Few data at higher fluences or with lower Cu.
- USE developed as upper-bound curves. Acceptance criteria for USE is in 10 CFR 50 Appendix G.
- The basis for the credibility criteria and use of surveillance data is not well understood.
- Attenuation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

Regulatory Guide 1.99 Background

- $ART = \text{unirradiated } RT_{NDT} + \Delta RT_{NDT} + M$
(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.

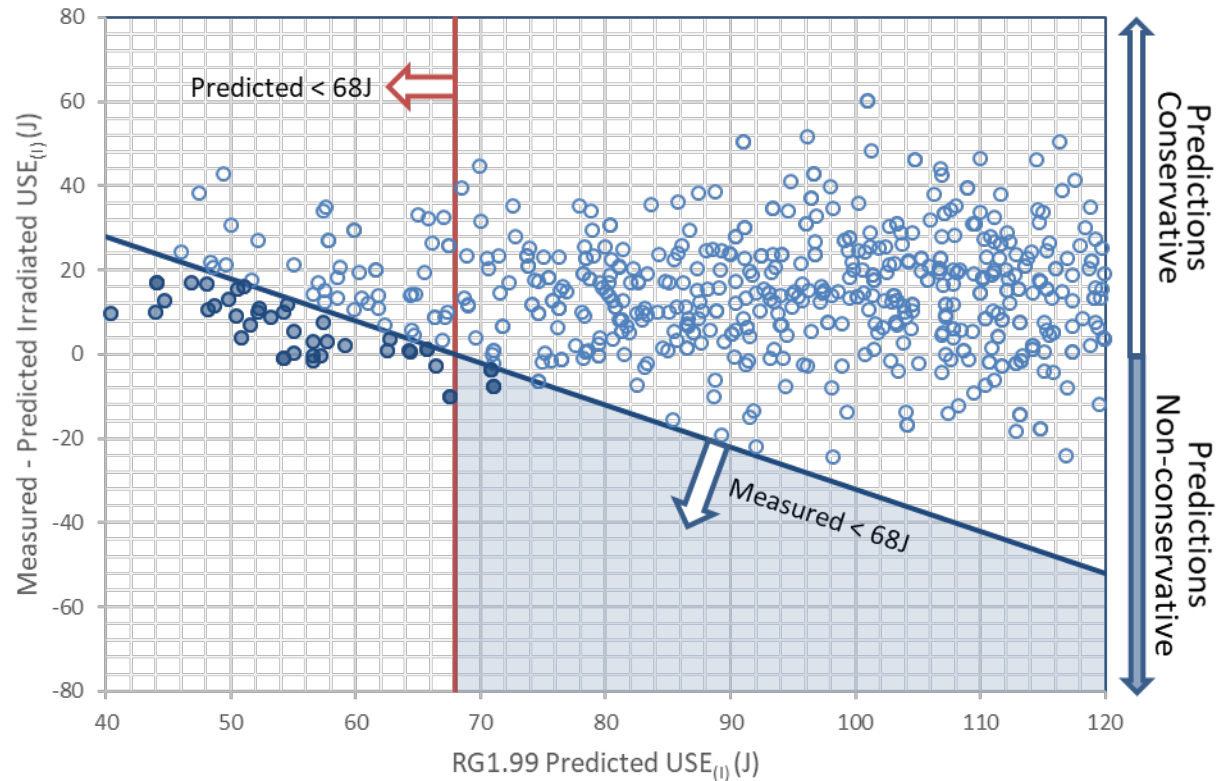
RT_{NDT} Results

- Primary conclusions:
 - Nonconservative high fluence results (base metals)*, becomes prominent at fluences $\geq 6 \times 10^{19}$ n/cm².
 - 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 1×10^{20} n/cm² (E > 1MeV)

Δ USE 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.

Δ USE Results

- 19% of materials measured Δ USE 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.*

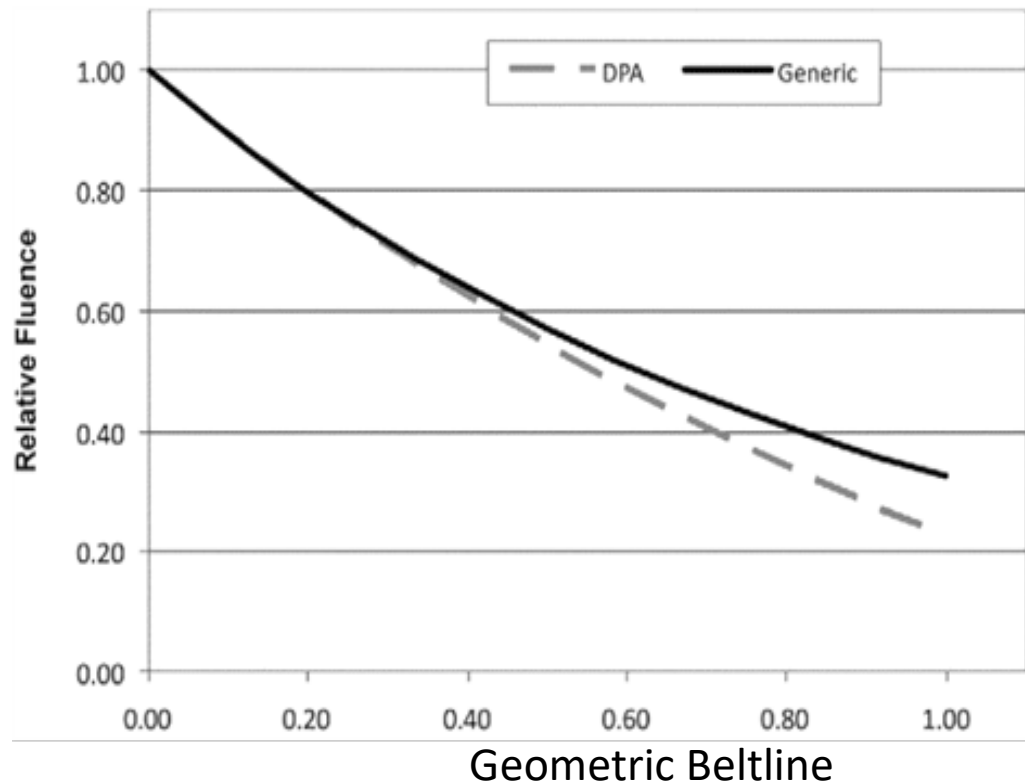
* - One or more surveillance data point outside 2σ where σ is the standard deviation of the ETC (17 °F for base materials and 28 °F for welds)

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.



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

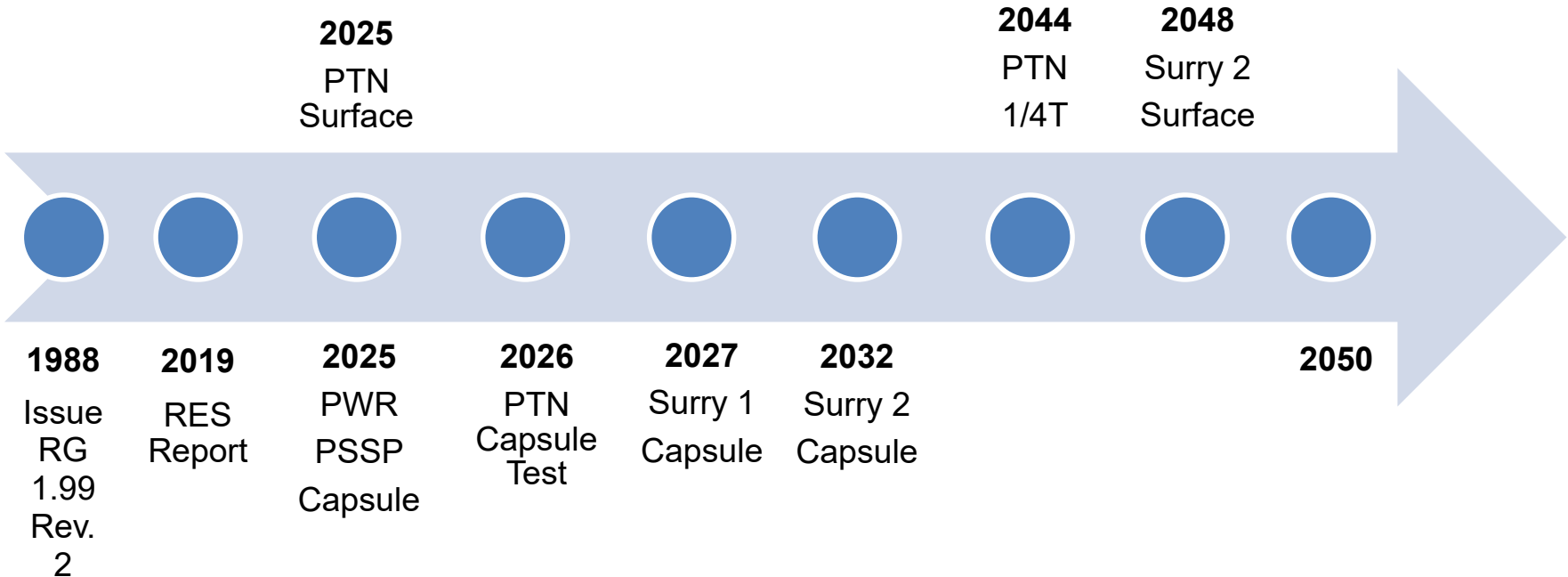
- Recommend an alternate ETC
 - *The working group selected the ASTM E900-15 ETC as the basis for the revision of RG 1.99, Rev. 2.*
- Determine limitations of ETC implementation.
- Determine how to apply surveillance data.
- Determine margins on ETC.
- Determine default values for inputs that are not 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 6×10^{19} n/cm²



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



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Potential Revision of *Regulatory Guide 1.99,* *Revision 2*

Tim Hardin
Technical Executive

Meeting of the ACRS

November 6, 2019
Rockville, MD



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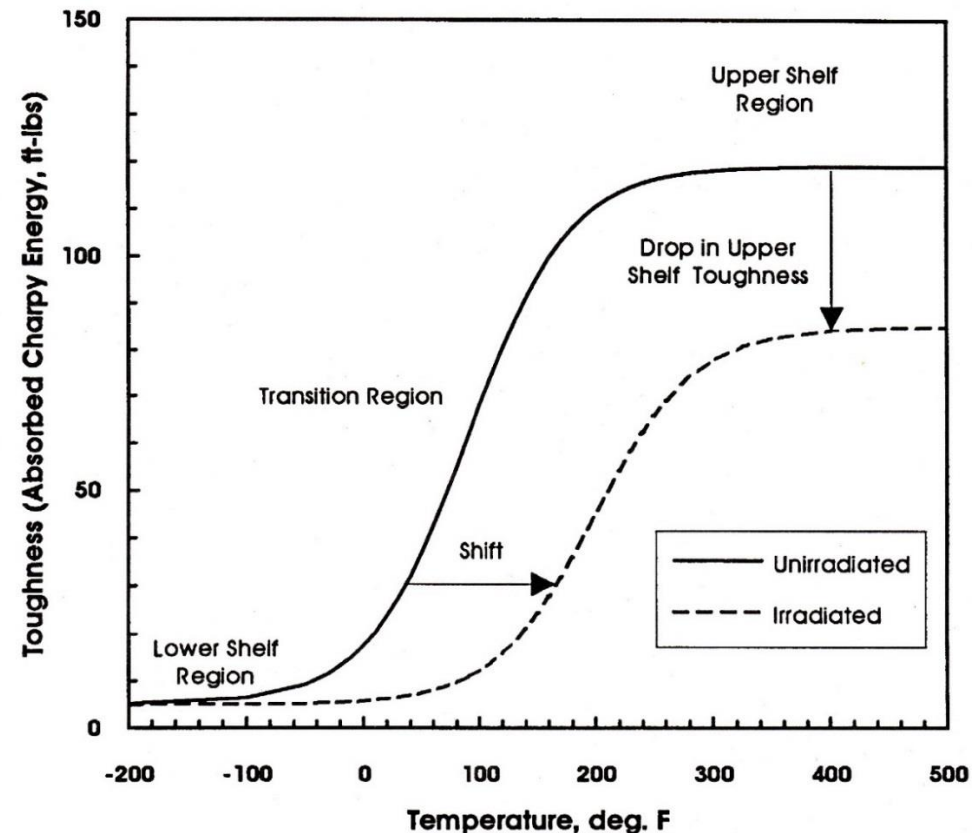
Contents

- 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} ($\Delta T_{30 \text{ ft-lb}}$) 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})

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

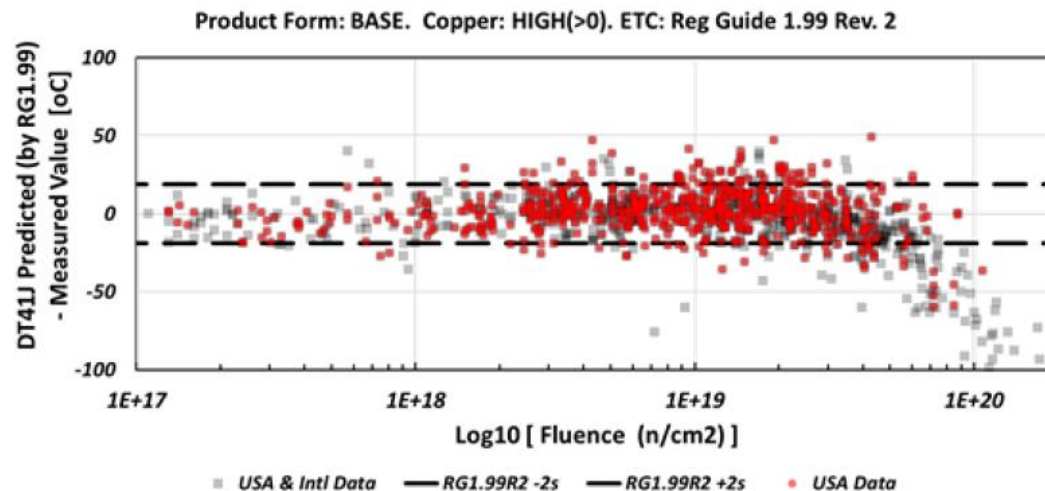
- In the August 22, 2019 Subcommittee Meeting, EPRI discussed a new USE prediction model developed by the Materials Reliability Program (MRP) in 2017 and published as MRP-414
 - *Materials Reliability Program: Prediction Model for the Decrease in Upper Shelf Energy of Reactor Vessel Steel Due to Neutron 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} ($\Delta T_{30 \text{ ft-lb}}$) 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 10¹⁹ n/cm² (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 10¹⁹ n/cm² (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 $\sim 3 - 6 \times 10^{19}$ n/cm² (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 1×10^{18} and 5×10^{18} n/cm²...while several plants are projected to have much higher fluence, on the order of 6 to 9×10^{18} n/cm²”
 - 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 $\sim 3 - 6 \times 10^{19}$ n/cm² (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

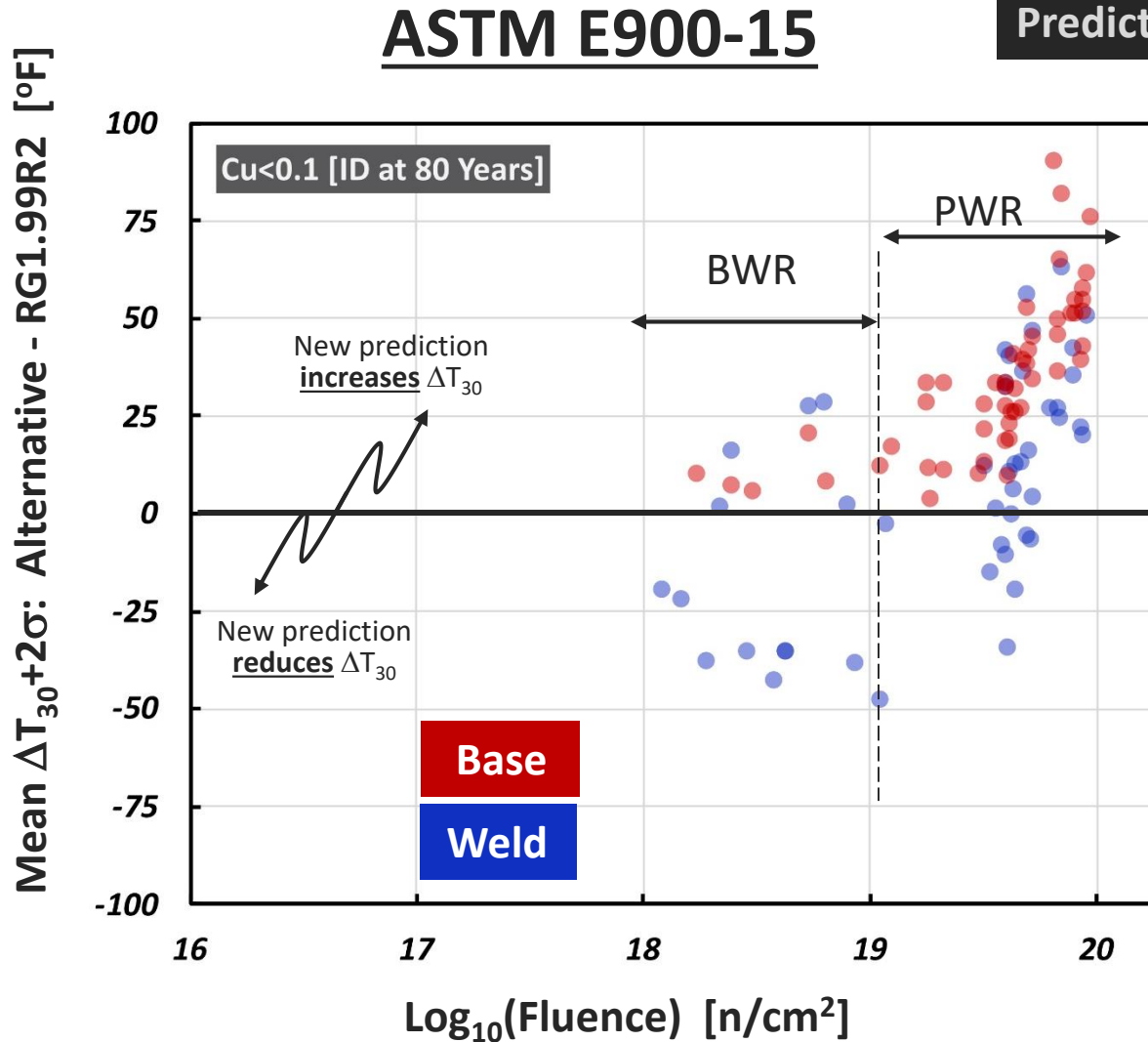
$$\text{Difference} = \Delta T_{30}^{E900-15} - \Delta T_{30}^{RG1.99R2}$$

- 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

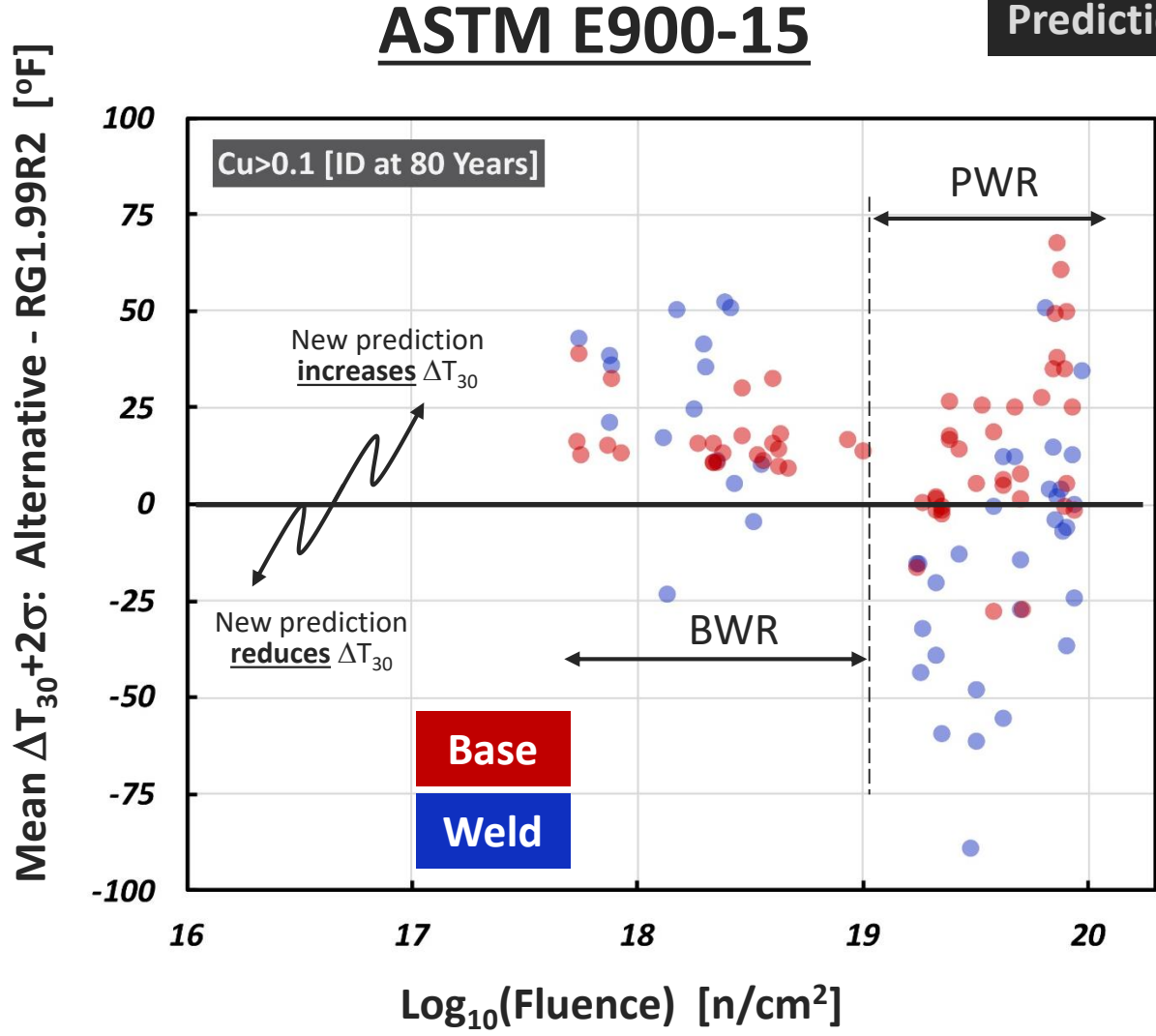
Time	Fleet @ 80 years
Copper	Low (<0.1 wt%)
Location	Inner Diameter
Prediction	Mean $\Delta T_{30} + 2\sigma$



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

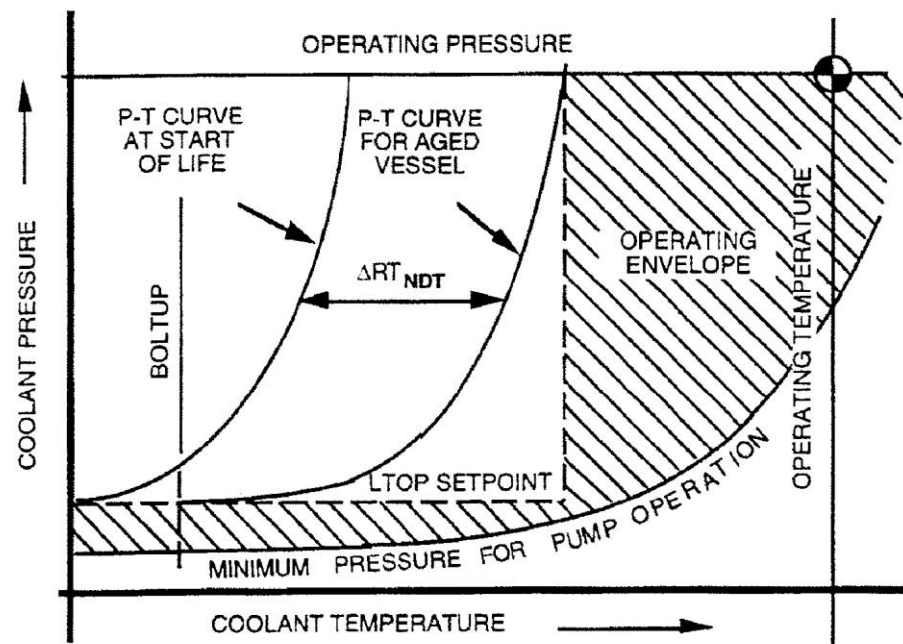
High-Cu Steels

Time	Fleet @ 80 years
Copper	High (>0.1 wt%)
Location	Inner Diameter
Prediction	Mean $\Delta T_{30} + 2\sigma$



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
 - In general, 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 $< 3 - 6 \times 10^{19}$ (e.g., the fluence level below which the TLR identifies no safety concern for the current RG1.99R2 prediction model)

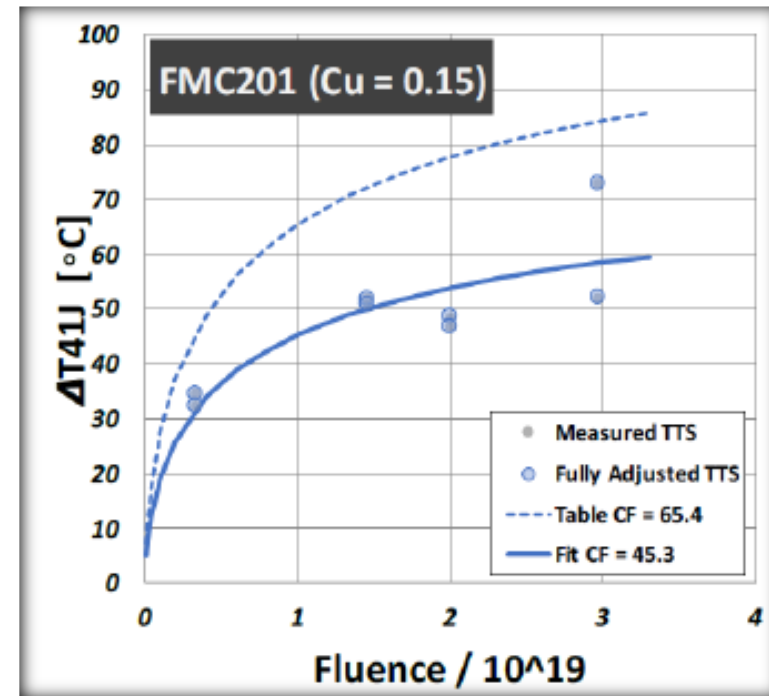


Figure from TLR-RES/DE/CIB-2019-2 illustrating consideration of surveillance data

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



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/TRIUM 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**



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.



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