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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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PUBLIC MEETING ON REACTOR PRESSURE VESSEL

EMBRITTLEMENT MONITORING AND

PREDICTION IN LONG-TERM OPERATION

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MONDAY,

OCTOBER 18, 2021

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The public meeting took place via Video Teleconference, at 1:00 p.m. EST, Joan Olmstead, NRC Facilitator, presiding.

PRESENT:

JOAN OLMSTEAD, NRC Facilitator

SCOTT BURNELL, NRC Public Affairs Officer

ALLEN HISER, NRR Senior Technical Lead

ELLIOT LONG, Principal Technical Lead, EPRI

DAVID RUDLAND, NRR Senior Technical Lead

STEWART SCHNEIDER, NMSS Senior Project Manager

ROBERT TAYLOR, NRR Deputy Officer Director

P R O C E E D I N G S

1:08 p.m.

MS. OLMSTEAD: Good afternoon. My name is Joan Olmstead, I am a member of NRC's Facilitator's Corps, and it's my pleasure to facilitate this afternoon's meeting. Slide two, please.

This is an information meeting with a question-and-answer session. And the purpose of this meeting held by the Nuclear Regulatory Commission, or NRC, staff is to meet directly with individuals to discuss regulatory and technical issues.

Attendees will have an opportunity to ask questions of NRC staff and provide feedback about the issues during the discussion and question-and-answer period. However, the NRC is not actively soliciting comments towards regulatory decisions at this meeting.

The public announcement for this meeting can be found in the Agencywide Documents Access and Management System, ADAMS, in the -- the number is ML21280A267. The NRC staff presentation slides can be found in ADAMS under the accession number ML21270A002.

So, thank you for attending this meeting. We are early in our review process, and this exchange of information of NRC staff evaluation of reactors pressure vessel embrittlement in long-term operation is important to the NRC's review.

The NRC staff discussion will include information related to the embrittlement trend curve in Regulatory Guide 1.99 Rev 2, Radiation Embrittlement of Reactor Vessel Materials. And in 10 CFR 50.61, Fracture Toughness Requirements for Protection against Pressurized Thermal Shock Events. And the surveillance requirements in 10 CFR Part 50, Appendix H, Reactor Vessel Material Surveillance Program Requirements.

This is an information-gathering meeting. And by the NRC's definition this means primarily the purpose of this meeting is to exchange information with members of the public and other stakeholders. The NRC staff will also answer process-related questions if time permits.

I'd like to note that the NRC has continued to operate in a largely work-at-home status, so most participants in this meeting are working remotely and individually calling in. We recognize this configuration presents unique challenges and continue to welcome comments about what is and what isn't working and with this meeting format.

Prior to the close of the meeting, I'll provide information on how you can provide your feedback on today's meeting, and your inputs helps us improve future NRC public meetings.

The agenda for our meeting is fairly straightforward. After a presentation by NRC staff, we'll have a presentation from the Electric Power Research Institute, EPRI, and we will then give the public an opportunity to provide feedback and ask questions of the NRC staff.

This meeting is scheduled from one to four p.m. Eastern Time. And we'll try to allow as much public input as possible, but we will generally try to adhere to the meeting schedule. Today's call is meant to be an exchange of information, and as always for NRC public meetings, no regulatory decisions will be made. Slide 4, please.

This slide notes speakers for this afternoon's meeting. Robert Taylor, Deputy Office Director for the Office of Nuclear Reactor Regulation, will be giving opening remarks, followed by David Rudland, NRR Senior Technical Lead for this project. Allen Hiser and Stewart Schneider are senior NRC staff that also support this activity.

And with that, I'll turn this over to Robert. Robert.

MR. TAYLOR: Thanks, Joan. Can everyone

hear me?

MS. OLMSTEAD: Yes, we can hear you.

MR. TAYLOR: Great. So I wanted to take the opportunity and open up this meeting and set a tone for the discussion that we're going to have today. And I'm excited to see the number panel -- or number of attendees who've shown up for the meeting and expressed interest in this. And we look forward to hearing perspectives and feedback during the meeting.

So for those of you who don't me, my name is Rob Taylor. I'm the Deputy Office Director for New Reactors in the Office of Nuclear Reactor Regulation, and I have the materials issues for operating plants under my responsibility as well. So I want to welcome everyone to today's meeting. This is an important topic as the NRC applies risk-informed approaches to its safety mission.

Today we will hear from the NRC staff about their efforts associated with monitoring and prediction of reactor pressure vessel embrittlement during longterm operation of nuclear power plants. The NRC staff is continuing a discussion of these issues that were first presented in a May 2020 public meeting.

During today's meeting, staff will describe a holistic risk-informed analysis they've performed on these issues and the potential impact on reactor pressure vessel integrity. I want to assure everyone that the NRC has high confidence that operating plants remain safe and currently the NRC regulations provide reasonable assurance of adequate protection against brittle fracture of the reactor pressure vessel.

Nothing in this meeting should be construed as undermining our continued confidence in the safe operation of these facilities. Instead, as with any proactive and scientific regulatory program, we should continue to assess new information and identify places where our regulatory programs may need enhancement in the future.

As such, today's meeting is intended to gather insights and perspectives on this topic, and we are not making any regulatory decisions.

The staff is proactively considering risk-informed options to address the combined effects of both issues of what we discuss today to ensure continued reasonable assurance of adequate protection against brittle fracture of the reactor pressure vessels during longterm operation. The staff is very interested to receive feedback from external stakeholders regarding the NRC staff's approach taken in a holistic risk-informed analysis.

Other potential efforts impact to plant operations that should be considered and if now is the appropriate time to pursue these issues. The NRC staff sincerely appreciates the external stakeholder interest in these topics. We're expecting a very interesting and productive meeting.

So with that, Joan, I will turn it back over to you.

MS. OLMSTEAD: Thank you, Robert. Slide 5, please. This slide provides logistic information on today's meeting. Please log into both the Webex and call in to the toll-free phone line. The audio is only through this bridge line. This arrangement allows us to minimize our bandwidth to have a more stable meeting platform and to help conduct the meeting's discussion and question-and-answer session.

If you're not on Webex and you'd like to view the presentation slides, they are in the NRC's ADAMS document database. And the session number for the package containing today's slides is ML21270A002. The session slide's ML number is also included in the public meeting announcement.

Today's call is on an operator-moderated phone line. Participants will have their lines muted until we reach the portion of the meeting where they can provide feedback and ask questions of the NRC staff. You'll be given instructions on how to participate before the discussion and question-and-answer session portion of this meeting.

As indicated in the agenda, we have allocated substantial portion of this meeting for this process. However, if participants would like to email questions to our public affairs officer during the staff's presentation, please email Mr. Scott Burnell at scott.burnell@nrc.gov.

Today's call is being recorded and will be transcribed. The transcription will be made available alongside with the published meeting summary. Given the number of participants we expect on the call and the format, I would ask that as a person speaks, they introduce themselves each time they speak. I also ask that the speakers limit their use of acronyms.

Your participation will be noticed in the meeting summary if you provide your information through Webex or the bridge line. Slide 6, please.

And now I'd like to introduce David Rudland, NRR's Senior Technical Lead, to discuss the purpose of the meeting and provide NRC's presentation. David.

MR. RUDLAND: Thanks. I'll do a sound check to make that you can hear me okay.

MS. OLMSTEAD: Yes, I can hear you, David.

MR. RUDLAND: Okay, great. Yeah, as introduced, my name is Dave Rudland, and I am a Senior Technical Advisor for Materials in the Division of New and Renewed Licenses in NRR. And I'm going to be going through the slides today.

The purpose of our meeting this afternoon is to continue the discussions we had, as Rob Taylor pointed out in the May 2020 public meeting, on two RPV embrittlement issues. The first being the embrittlement trend curve in Regulatory Guide 1.99 Rev 2, which is also in 10 CFR 50.61. And it's, the issues with that trend curve at high fluence where the predictions appear to be in some circumstances under-predictive of the measurements.

And the second issue is to talk about Appendix H, the surveillance testing program. This is 10 CFR Part 50, Appendix H. And we'll be looking at those issues and those circumstances where some capsules have been delayed, leaving large gaps between surveillance tests.

We talked about the technical details at that particular public meeting, so I'm not going to go over those details again. I will talk about, briefly talk about the issues but won't go into the details that we did in that public meeting.

I will be discussing a holistic risk-informed analysis that looks at both of these issues together and its impact on vessel integrity. And again, this is a risk-informed analysis that takes a look at the complete issue.

As mentioned also this is going to be mainly a technical discussion, and no regulatory decisions will be made. We'll be talking about some options that the staff is considering about how to move forward, so of course we would like feedback not only the analysis results that I'll be presenting, but also on some of the options that we discuss later on also. Next slide, please.

Before I get into the issues, I wanted to kind of give a quick background on how the monitoring prediction of embrittlement works. Within this Regulatory Guide 1.99 and 10 CFR 50.61 there is an embrittlement trend curve, and that trend curve predicts changes in fracture toughness as a function of fluence. The embrittlement is measured by a change in the transition temperature from a brittle fracture to a ductile fracture.

As you can see in this -- in the left illustration, there is a measure of embrittlement at the beginning of life. The red curve demonstrates a trend that is predicting an increase in embrittlement with an increase in fluence.

In addition to that, surveillance capsule testing provides monitoring to ensure the embrittlement trend curve predicts the plant-specific behavior properly. And the data left plot is illustrating how the data would fall in the embrittlement trend curve predicts the behavior properly.

Within the regulations, a margin is added to those predictions from the trend curve, producing something called an adjusted reference temperature. That adjusted reference temperature is then used in the regulations such as 10 CFR 50 Appendix G to predict the pressure temperature limits for normal operation, which is shown in an illustration in the right figure.

You can see illustrated pressure-temperature curves for 40, 60, and 80 years and how those curves move to the right as the vessel becomes more brittle. And what that does is that shortens the window, it reduces the size of the operating window for a plant to cool down. All right, next slide, please.

So the idea scenario for these two working together is that you have ETC that provides accurate or conservative predictions of embrittlement and surveillance data that covers all operating periods. Because Appendix H lists that that is type of data should be pulled periodically throughout the life of reactor.

However, you can have certain circumstances where you may end up with uncertainty in those predictions. For instance, as illustrated on the left figure again, you can have an embrittlement trend curve that may under-predict the measurements. As you can see, the orange and pink data illustrate that the red curve under-predicts that behavior. That could have a source of some uncertainty.

Or, as illustrated in the picture on the right, you may have limited data or no data at high fluence, in which the uncertainty is even larger in how well the embrittlement trend curve predicts the actual embrittlement state of that particular material.

And so each one of these conditions could have uncertainty and could add to the issues with the embrittlement trend curves. Next slide, please.

Illustrating that a different way, as you can see at the top figures, if we have reasonably periodic measurement of embrittlement and an accurate embrittlement trend curve, then you have an expected amount of uncertainty, which is illustrated in the upper righthand figure by the blue dashed lines.

And our margins and regulations are based on the amount of expected uncertainty. However, like I mentioned, if you have missing data or, and/or an embrittlement trend curve that may under-predict the behavior, you could have an increased amount of uncertainty.

And with that increase amount of uncertainty, we are not sure that we understand what the impacts of that uncertainty are on future predictions of embrittlement. And so this holistic analysis was needed to really understand what the impacts of that uncertainty -- impacts for that uncertainty are on the behavior of the vessel. Next slide, please.

So our current perspectives on this potential issue. As Rob pointed out, we have high confidence that the current operating plants remain safe and that all of our current and recent licensing actions remain valid.

However, with some insufficient embrittlement monitoring and under-predictions of the embrittlement trend curve, we may have an impact on the confidence in the integrity of the vessel in longterm operations, in that safety margins and performance monitoring may be impacted.

And what we feel right now is that we need to do future work in order to determine which plants are impacted by this potential issue. I'll go into that a little bit more as we go through this presentation. Next slide, please.

So I'm going to go into some details right now about each of the issues, just briefly touching on the issues before we go into the holistic analysis. In May of 1988, the NRC published Regulatory Guide 1.99 Rev 2, which contained an improved embrittlement trend curve that was fit on 177 surveillance data points.

And then in June of '91, the NRC updated 10 CFR 50.61 to include that same embrittlement trend curve that was in Regulatory Guide 1.99 Rev 2 to address some issues that were being had with lower than measured predictions of the current -- of the embrittlement trend curve that was in 10 CFR 50.61 prior to that update.

More recently, the embrittlement trend curve was reevaluated for continued adequacy in 2014 and in more detail in 2019. Those evaluations are public and the ADAMS accession numbers are shown on this screen for more information. Next slide, please.

To go into some, a little detail about what we're seeing with the embrittlement trend curve, this plot illustrates that behavior. On the Y axis, on the vertical axis, this is a measure of the difference between the embrittlement predicted by Regulatory Guide 1.99 Rev 2, the difference of that value versus the measure value from surveillance data.

So a value of zero on this vertical axis represents a perfect prediction of embrittlement from that trend curve. The X axis is an increase in fluence. And what you see is that you have a pretty good prediction through most of the fluence history.

You have some scatter in the data. The solid -- I'm sorry, the dashed heavy lines represent the standard deviation in the data, the scatter in the data as expected by Regulatory Guide 1.99.

As you get higher and higher fluence, the scatter in the data becomes greater. And at 3E to the 19th fluence, the trends begin to deviate from that. I should point out that the red points on this plot are US data, US surveillance data, and the gray points are from international data.

At about 6E to the 19th, the data becomes statistically significant in that the deviation becomes greater than that two standard deviation that I mentioned. And by the time you get to about 1E to the 20th neutrons per centimeter squared fluence, you can have about up a minus 180 degrees Fahrenheit of under-prediction of embrittlement.

And again, remember, in this case embrittlement is being measured by a shift in the transition temperature. I will go into some detail, a little bit, of that temperature means and what the significance of that temperature is in a few slides. Next slide, please.

This is a plot for -- the prior plot was for base metals. This particular plot is for weld metals. And you see a similar behavior. You have good predictions at low fluence. However, as the fluence gets larger, the scatter is getting -- the scatter is getting bigger than what was predicted from Reg Guide 1.99.

However, at high fluence there's limited data. And so you don't see the downward trend, probably due to the lack of data at this particular time. Okay, next slide, please.

Each of this is being driven by the fluence function within the embrittlement trend curve in Regulatory Guide 1.99. The embrittlement is predicted with that trend curve through a combination of information from the material chemistry, as well as the fluence. This equation that's at the top of the chart shows that equation for predicting the embrittlement.

CF is a chemistry factor that's a function of nickel and copper. And then the fluence function "f" is from the next part of the equation. And what's plotted on this particular plot is that fluence function as a function of fluence. And what you -- and what we see is about that about 3E to the 19, the fluence function begins to -- the slope begins to change and actually reaches a peak and begins to decrease.

This point at which this inflection occurs corresponds to the same fluence levels where the under-prediction begins on Slide 12. It's unknown right now whether or not the actual fluence function should follow that light blue line, or whether it should increase slightly or decrease slightly. But we know that following the dark blue line causes this, some of this under-prediction to occur.

And the reason why this is there is because at the time when this was developed, there was a limited data. It was like I mentioned earlier, only 177 data points. And so when you extrapolate the curve beyond the area in which we had data, that behavior occurs. All right, next slide, please.

All right, so that's the main issues with the embrittlement trend curve. I'm going to move now to surveillance capsule. Appendix H from 10 CFR Part 50, as I mentioned earlier, requires periodic monitoring of the changes in fracture toughness due to neutron embrittlement. The regulation incorporates by reference an ASTM standard, E185, that sets up the testing surveillance schedule of details for a program.

And these programs are typically about three to five capsules. The capsules include material property specimens that are placed inside the core, closer to the core than the reactor vessel wall.

They're pulled at certain times and tested to try to get a future behavior of embrittlement. The

ASTM standard allows the last capsule, the final capsule, to be pulled and tested at two times the reactor pressure vessel design fluence.

Realizing that E185-82 was originally really designed for 40-year lives, the last capsule -- I'm sorry, the second-to-last capsule was meant to be tested at a fluence that was corresponding to about 40 years' life. And the last capsule therefore could be tested at a much higher fluence.

And in fact, the ASTM standard allows for holding and not testing that last capsule if you're able to get the fluence, the correct fluence in the first few capsules.

However, as we've moved to license renewal and to subsequent license renewal, those particular lives have changed from 40 years to 60 years and 80 years. And so that particular capsule continues to be moved out.

In '97, the Commission made a finding related to the Perry Plant that any time a staff reviews a request to change a capsule withdrawal schedule, it's limited to a verification or a conformance kind of check to the ASTM standard. There can't be a technical or safety check.

And because of the extended design lives, the change in the design fluence capsules and the testing has been repeatedly delayed in some cases to achieve to higher and higher fluence. Next slide, please.

So as we went into license renewal, the regulations -- the staff decided the regulations did not need to be changed, that the surveillance programs could be addressed in the guidance. And the guidance now provides flexibility to let the licensee demonstrate adequate aging management.

Within the GALL reports, there are several statements relating to these capsule programs. In NUREG-1801 Rev 1, there's a statement that at least one capsule with a projected neutron fluence equal to or exceeding the 60-peak fluence needs to be tested -- needs to be tested.

In NUREG-2191, which is the GALL-SLR, there's a similar statement that says withdrawal and testing of at least one capsule with a neutron fluence of the capsule between one and two times the peak neutron fluence of interest at the end of the subsequent period of operation need to be tested. And it also specified that it's not acceptable to redirect or postpone the withdrawal of testing to reach a higher fluence level. Okay, next slide, please.

What's happening in practice, however, is that licensees are changing their capsule withdrawal schedules prior to application. And this is only in some cases. Prior to application for license renewal or subsequent license renewal. And that change is being evaluated under the current approach of conformance, consistent with the Commission guidance for earlier.

And then the current license basis surveillance programs then are consistent with the GALL program once they receive that conformance review and approval. Next slide, please.

So this shows an example of one of those cases. And in this particular figure, the Y axis again is a measure of neutron fluence. The X axis is the date at which a surveillance capsule was pulled and tested. The black circled data points represent one particular plant that has pulled four capsules. And you can see the years in which they were pulled.

Their last capsule was pulled around the time of 2008 or so. Their fifth capsule was to be tested at that first X, the orange X mark, which was about 2009. And as you can see, it was moved a total of four times, now to be tested somewhere around 2025.

There have been a lot of licensees that

have delayed capsules. Some examples are shown on this slide. But I do want to point out that not all plants have delayed their withdrawal capsules. Many have not, but some have.

And these changes have not been against the guidance or the regulation. They have been moved properly with the appropriate approvals. All right, next slide, please. Hit one more time, please.

This is just another example to show of the impact of this. This is this plot I showed earlier of the difference between predicted and measured embrittlement as a function of fluence. The green lines on the plot show the four early surveillance data points.

And what you can see is that all four of those fall within that range in which the embrittlement trend curve does a good job at predicting the embrittlement.

This particular plant's 60-year mark and 80-year mark are shown in blue. You can go one more forward. And their fifth capsule is to be pulled in 2026, which is not until the 80-year mark, which is about 1E to the 20th. Or they could have up to a minus 180 degree under-prediction in their embrittlement.

And you can see here there's 25 years in between when the last capsule was pulled and when the next capsule is planned. Okay, next slide now. One more time please.

This is a plot, again, a different way to plot this. Embrittlement on the Y axis, on the vertical axis, fluence on the horizontal axis. The four data points I talked about earlier, you can see how they are. One more time forward, please. If they were to use Regulatory Guide 1.99 and only use the material chemistry and the fluence, this was the embrittlement trend that they would get, this orange line.

The Regulatory Guide also allows them to fit the data to adjust their embrittlement trend curve. So if I take those four data points and I adjust the embrittlement trend curve for those four data points, I get the blue curve, which they can use. So at 1E to the 20th, they have a embrittlement measurement of about 230 degrees Fahrenheit.

If they were to test it and the tests were to show the under-prediction that was suggested in the previous slide, they could have about 150 degrees of under-predicted from their -- from that blue line or the adjusted embrittlement check.

If I assume those two data points are actual and I refit those using the procedures in Regulatory Guide 1.99 Rev 2, I would get this yellow line. Even with this yellow line, I still have under-prediction of -- hit one more time please. I still have an under-prediction of about 75 degrees, because again, the fluence function does not properly predict the behavior of the embrittlement.

Because of that flattening off and decrease, the embrittlement trend -- or even when I fit the data would not be an appropriate fit. In actuality, the data would be a not credible because of the differences between the data and embrittlement trend curves, and the Regulatory Guide 1.99 would tell them to go back and use the original curve, the orange curve.

So there could be, even if we have the data, there could still be issues with the embrittlement trend predicting -- under-predicting the actual behavior. Next slide, please.

So with those two issues that I talked about, the under-prediction in embrittlement from Regulatory Guide 1.99 and the same trend curve which is in 50.61, and this issue with delaying the capsules in Appendix H surveillance programs, the staff wanted to understand what the combined impacts were on safety. And they used a risk-informed approach that leveraged the five principles of risk-informed decisionmaking.

And we wanted to make sure that not only did we look at these five principles, but we kept in mind the conditions in which this -- these issues were of concern. And so we tried to choose a targeted sample of plants to do this analysis on and use the data that we had, but there was much plant-specific information that was not available. And I'll talk a little bit about that in terms of uncertainty here in a couple of minutes. Next slide, please.

One of the main assumptions that we used at the beginning was we wanted to compare the embrittlement trend curve results from 1.99 to ASTM E900-15 embrittlement trend curve. And we did that because the staff found that this particular trend curve provided the most accurate characterization of the database of material.

This database of material that I've shown here was what ASTM used in making -- in developing this particular embrittlement trend curve. And the staff report where the staff did this evaluation is shown below. The ML number for that is shown below.

And what the data shows here is that -- is that the predictions are good for most of the fluence levels. Even the standard deviations seem relatively reasonable if you don't see that dropoff in either the base metals or the welds. So we wanted to use this as a baseline. Next slide, please.

So the assumption that we used in the analysis was we targeted a sample of 21 plants. We focused on high fluence plants, because again, this issue seems to be focused on fluences that were greater than about 3E to the 19. But we included some low copper plants or plants that weren't accessible to embrittlement, and some BWRs to kind of round out the sample of plants that we looked at.

And we -- from those samples and the data we had, we determined the changes in this adjusted reference temperature, or this transition temperature shift from moving from (inaudible) -- I'm sorry, can everybody still hear me? I had a lot of static come through the line.

MS. OLMSTEAD: Yes, I can hear you now.

MR. RUDLAND: Okay, all right, I'm sorry. I don't know where that static came from.

And so we calculated what the switch in adjusted reference temperature was from going from

Regulatory Guide 1.99 Rev 2 to E900-15. And we titled that the embrittlement shift delta, and we used this embrittlement shift delta to benchmark and to focus our risk analyses. Can we go to the next slide, please.

So what we found out from this is that there is a tendency for the reference temperatures that we're talking about to increase when switching from Regulatory Guide 1.99 to ASTM E900-15. And we say it's a tendency. It didn't happen in all cases, but on average it seemed to -- the reference temperature seemed to increase. And the base metals were more likely to see that increase than the weld metals.

Most of the cases only had a shift that was about 50 degrees. There were some that had more than 50 degrees, but not very many. And those that did have a shift of more than 50 degrees tended to be fluences that were around 6E to the 19. And I'll talk about the impacts of that in one second.

But this range of ESDs, or the embrittlement shift deltas, is what we assumed in the risk study that I'll talk about here in a second. Next slide.

So the staff did a variety of probablistic fracture mechanics analyses looking at these impacts. They looked a variety of conditions, a variety of transients. Looked at a variety of flaw sizes, both 1/4T flaws and small surface breaking flaws, to determine if their -- determine what the impact was going to be.

This particular plot is for a 103 per hour cool down where the transient follows the PT curve. If you could hit the next slide, please. So for this particular plot, there is a -- there's two things. There's the conditional probability of failure curves and conditional probability of initiation.

And for the conditional probability of failure, a 50-degree embrittlement shift delta gave about two orders of magnitude, or two, or two and a half orders of magnitude change in the conditional probability of the failure.

At 150 degrees, if you hit the slide again, please, there is about six order of magnitude changes. So it's relatively a large change in additional probabilities of failure for these embrittlement shift deltas. But there's a lot of uncertainties. The main one is the frequency of the transient.

The frequency of following the PT curve

during cool down is very low. And so what that is is it's still a little bit uncertain. There's a lot of plant fluence variations. We're unsure if these analyses are bounding. There's a lot of plant-specific considerations that need to be taken into account.

And as always, we know that there are administrative and operational controls in place against violating PT limit curves and how much protection do those -- do those really give.

Details of this analysis, there's a summary slide the next slide, but the details of this analysis can be found in the reference that's shown at the bottom of this slide. And the ML number is given there.

So the summary of the results, if you go to the next slide, illustrates that in most cases, the conditional probability of failure was low or less than 1E to the minus 6 from those conditions. And for those conditions that were greater than 1E to the minus 6, there was some uncertainty.

But the staff felt that through-wall crack frequency, which again is the conditional probability of failure times the transient frequency, remains below 1E to the minus 6. But we felt a bit uncomfortable because of these uncertainties.

There needed to be some additional information that may be required to determine for at high cool down rates it might be possible. And to really understand what the event frequencies are, in all cases, not just following the PT curve, will help us to gain confidence that the risks are low. All right, next slide, please.

We also looked at pressurized thermal shock. That prior slide was for normal operations. In pressurized thermal shock, again, 10 CFR 50.61 uses the same embrittlement trend curve for as Reg Guide 1.99. And this RT-PTS that is calculated in that regulation might be impacted.

There's a screening criteria which is shown here of 270 degrees F for -- plates, forgings and axial welds at 300 degrees F for circ welds might be impacted. And actually if the embrittlement trend curve was changed, some might actually pass this screening environment.

However, for the sample that we took, for the plant that we sampled, we calculated the through-wall crack frequencies for pressurized thermal shock with the corrected embrittlement, and it was less than 1E to minus 6 for all cases investigated. So the risk for pressurized thermal shock for these issues is relatively low. All right, next slide.

So even though the risks are low, the uncertainties are high, and the uncertainties are increasing with time. And really taking care and fixing these issues will help us maintain the -- the fundamental safety principles that went into developing the regulations and the basis for plant design and operation.

And really, safety margins that we need to take a look at, as provided by the regulation, provide reasonable assurance against brittle fracture. All right, next slide.

I'm going to illustrate what I'm talking about in this particular -- in this particular way. This particular plot showed an illustration of a pressure-temperature curve. The area to the right, typical operating window, shows, excuse me, the area in which typical plants cool down. So they'll start at a high pressure, high temperature and decrease the pressure and temperature to stay inside this window. Next, please.

There is a structural limit, and that structural limit is where if they -- if the particular plant were to cool down too fast and not reduce pressure, they may pass that structural limit and have a large chance of a brittle fracture. Hit, go again.

The orange curve demonstrates an accurate PT curve, and that accurate PT curve provides significant margin -- can you hit one more time, please. Provides adequate margin between the structural limit and the operating behavior. And you notice there still is some gap between the PT curve and the operating window, and that is usually due to operational limits. Can you hit again, please.

And that adequate margin that we have between the structural limit and the regulated PT curve is directly proportional to each other. So that the margin and the uncertainty are well aligned. One more time, please.

However, if we use the current Reg Guide 1.99 and you have a condition where you are under-predicted the behavior, you can have a PT curve that shows -- that's shown like this. One more time, please.

And while this line defines the operating margin between the PT curve viewed in Reg Guide 1.99 and the operating window, you may actually have a smaller operating window because the actual PT would be the orange line. And the margin to structural failure -- hit one more time please. The margin is actually reduced due to this under-prediction. And that is going against typically how we develop margins. You can hit more time please.

Typically as the margins -- as the uncertainty increases, we like to have larger margins since we -- since we're uncertain. But in this particular case, the margin is decreasing while the uncertainty is increasing.

And this increase in uncertainty and reduction of margin is leading us to evaluate the behaviors in these two -- in both Appendix H and the embrittlement trend curves in Reg Guide 1.99. Okay, next slide, please.

And again, we also could talk about performance monitoring. Appendix H, as I mentioned earlier, allows for the periodic testing, which allows us to make sure that an analysis remains valid and the that the embrittlement trend curves properly predict the plant-specific behavior, and to make sure that there's no unexpected safety issues that may occur.

To delay capsule withdrawals or having an extended period between capsule withdrawals represents a lack of performance monitoring. Next slide, please.

So in summary, and the with the current

state of knowledge, the generalized analysis suggests that the overall risk of brittle fracture is low. The uncertainty really is high, but it's increasing with time, especially with the conditions that may be occurring at high fluence with an under-prediction in the Reg Guide trend curve and the delaying of surveillance capsules.

In our particular analyses, though, the plant-specific details really were not considered because we didn't have a lot of information. We used the information that we had. And so that adds to the uncertainty that we had. And under certain conditions, the safety margins may be impacted and are probably decreasing as the uncertainty increases.

As I mentioned, delaying capsules represents a lack of sufficient performance monitoring. But most of these issues are focused on plants or conditions where the fluences are excess of 6E to the 19 neutrons per centimeter squared. All right, next slide, please.

So who is impacted? Using some data from the MRP, we can estimate that at about 60 years, about nine percent of the PWRs surpass the fluence level of 6E to the 19 neutrons per centimeter squared at the ID surface. And by 80 years it's about 34%.

The differences between the columns to the left and the columns to the right are the BWRs, which really are not impacted by this because they are -- they operate and will operate through at least 80 years at a much lower fluence.

For those percentages of the -- of the plants that I'm talking about, plant-specific details, such as remaining material and other things, really may contribute to which plants are impacted. And again, more work is needed to determine how or if any of those plants are truly impacted.

In terms of surveillance data, any plant that has renewed its license that chooses to delay the last capsule will be impacted. Those plants that are in an integrated surveillance program will not, will not be impacted. All right, next slide, please.

So what are our goals? Again, like I mentioned early on, the staff feel that the regulations are sufficient for a reasonable assurance of adequate protection against brittle fracture. But we want to make sure that as we move on into the future -- as we move on into the future we continue to have reasonable assurance.

So we want to provide remedies to the identified solution -- to the identified issues with the RPV surveillance requirements and the under-predictions of embrittlement. We want to do that on a risk-informed performance basis.

And we want to make sure that we don't impact those plants that are not adversely affected. The plants that have surveillance data that covers the end of their license fluence level, and/or those that may have a fluence that's less than 3E to the 19th -- 3E to the 19th neutrons per centimeter squared. Next slide, please.

So the staff is considering options, and those options can range from a plant-specific action, maybe a focused regulatory action, generic communication, or possibly no action. So within this discussion, we'd like to talk about these kinds of things. If we can go to the next slide please.

Some of the things that we would like to talk about are the options that I just mentioned of whether or not the staff's approach that we took. Looking at this thing holistically is appropriate, seems to be appropriate. Are there other options that we have not considered, or that we should consider? Are there any other potential impacts to the plant that need to be considered that we didn't consider already? Unnecessary updates to PT limits is just one of those.

And is this the right time to pursue these -- to purse these issues and to make a change on these issues. I need to say again that the NRC is right now is not actively soliciting any comments towards a regulatory decision at this meeting. This is more of a information-gathering session to understand people's point of view. Okay, next slide, please.

Okay, so in summary, as I mentioned earlier, the staff has high confidence that the operating plants remain safe and that recent licensing actions remain valid. The issues that I described here may impact the staff's confidence in about ten years that the integrity of the vessel for longterm operation because of safety margins and performance monitoring may be impacted.

We need to do further work, especially plant-specific work, to determine which plants are impacted, but we want to be proactive, and we want to be able to assure continued reasonable assurance and do that through a risk-informed, performance-based solution.

We are considering options. Our desire has been and will always be to try to focus that solution on only those conditions that are impacted by this issue.

I think that's my last slide. There's no next slide. Okay, so that's the end of my presentation. I need to now turn the presentation over to Elliot Long from EPRI. Elliot Long is a Principal Technical Leader at EPRI. He will be making a presentation on behalf of EPRI.

MS. OLMSTEAD: Thank you, David. Operator, can you please unmute Elliot Long's line, please.

OPERATOR: Elliot Long, your line is now open.

MR. LONG: Hello, everyone, can you hear me clearly?

MS. OLMSTEAD: Yes, we can.

MR. LONG: Excellent.

MS. OLMSTEAD: Elliot, I cannot hear you now, though.

MR. LONG: (Simultaneous speaking.)

PARTICIPANT: Elliot's slides.

MR. LONG: On the --

MS. OLMSTEAD: Yes. All right, we see the slides now. And can you put them on the slide view. Okay. All right, that should work, Elliot. Thank you.

MR. LONG: Thank you all very much. As was noted, I am Elliot Long. I am a Principal Technical Leader with the Electric Power Research Institute, and I'm going to make a presentation today discussing some of the industry initiatives to help generate high fluence data. So next slide, please.

As I noted, we have two ongoing industry and EPRI MRP initiatives to generate additional sources of high fluence capsule data. The first of these is the Coordinated Reactor Vessel Surveillance Program. And then the second is the PWR Supplemental Surveillance Program, or PSSP.

I also want to revisit the conclusion made by our colleague, my colleague Kim Hardin back in November of 2019 at the ACRS meeting, and then talk briefly about the potential impact of PT limit curve as it regards to this current issue.

Before I move forward, you'll see the red star. I don't have much about BWR units in this, it's mostly a PWR discussion. However, the BWR units do have an NRC-approved ISP, Integrated Surveillance Program, through 60 years of operation. In addition to that, there is an implementation plan for subsequent license renewal that has also been accepted by NRC. I see the report title there.

The second report does note that the highest BWR units will not exceed the threshold for fluence of 6 times 10 to the 19th during (inaudible) an SLR time period. I just wanted to point that out that we'll mostly be focusing on PWRs here. And I do have some additional information on slide 12 in regard to that fluence topic. Next slide, please.

So we'll first talk about the CRVSP, Coordinated Reactor Vessel Surveillance Program, as documented in MRP-326, now Revision 1. Next slide.

The original intention of this program was to optimize the remaining and existing US PWR surveillance capsule withdrawal schedule to increase the amount of high fluence data that can be generated by the remaining capsule. This new data can then be used to inform embrittlement trend correlations and generate data from 60-plus years of operation.

The original revision from 2011 did just that, wherein we reviewed every US plan, PWR plan, surveillance capsule schedule and recommended changes to maximize and optimize the high fluence data that can be achieved by the current capsules that remain through 2025. This year, the EPRI MRP did a revision to this report, basically to review how we did, what has happened, what's changed, what's left to do, and see if anything needs to be updated to continue moving forward with plan.

The updates include checking the evaluated capsule since 2011, revisiting future capsule pull schedules, documenting updated capsule fluence values, and then assessing the impact of closed or to-be closed plants on the overall plan. Next slide.

As you can see, we have now tested 16 out of the 30 CRVSP capsules. They're either already tested or planned to be tested. The remaining 14, there are 14 left of these, about half will not be tested for a variety of reasons. Some due to plant shutdown, some have been delayed beyond 2025.

In summary, as of this summer, we have 48 capsules in the US that have a tested fluence greater than 3 times 10 to the 19th. Four of these are over 8. By 2025, those remaining seven CVRSP capsules will also be tested at fluences greater than 3E 19, and two of those will be over 8 times 10 to the 19th.

This report also did a first update to the schedule for when the PSSP PWR Supplemental Surveillance Program capsules will be withdrawn. The first one will be Farley One, Capsule P, in the spring of 2027. And then in the following fall of 2028, Shearon Harris Capsule P will be ready.

And that leads me into the next slide, where we discuss the PSSP. So next slide again. This program was developed to generate additional again high fluence data that has a very similar objective to the prior program, inform future ETC development applicable to the RPVs at higher fluence.

This one was a targeted approach designed to fill in the gaps of materials in the capsule database. It also was designed to irradiate these materials in commercial reactors since we were generating data from commercial reactors and not from test reactors.

The end game really says it all, we fabricated two supplemental capsules and irradiated them for ten years. That's the current status before we withdrawal test and evaluate those materials. These two capsules contain 288 Charpy Specimens from 27 unique plates, forgings, and welds.

The data will ultimately yield 24 new transition temperature shift results, and then three of the materials will shift just generate an upper shelf energy.

You can see the fluence ranges at the bottom. I will stress that all of the materials in these capsules were from previously irradiated and tested surveillance capsules. So they were already irradiated at a plant.

They were refabricated into new specimens and are going back in to generate the higher fluence levels shown there, 4.5 on 10 the 19th upward to 1.2 to the 20. So each individual component will have its own unique fluence value. Next slide, please.

So as I said, the program fabricated two supplemental capsules containing previously irradiated and reconstituted PWR materials. The EPRI MRP sponsored the fabrication and the host plans are shown there.

Farley One went in in October of 2016. So it'll have about 11 years, ten and a half of irradiation. And then Shearon Harris has the second one. It'll also have about a little under ten years of irradiation in that vessel. The published report was shown there in 2016. Please go to the next slide.

2027, the Farley Capsule P will be withdrawn and Shearon Harris in 2028. You can see at the right we took broken Charpy Specimens, the top right image, machined one half of one side down to an insert, so that middle piece is actually the material of interest. We then welded end tabs of standard material on either side both into the middle picture.

Machined them flush and cut them to standard Charpy size.

These are the materials, the 288 of the bottom image there on the first caption, the first figure, are in the capsule. They're going to be evaluated starting into '27, 2027 and 2028. It'll take a couple of years to get all that analysis done.

Hope to have the two capsule reports ready towards the middle within 18 months of the withdrawal. And then we'll spend the early part of the 2030s evaluating the data and the impact on any future ETCs for the existing ones or the need to develop new ones.

And then I showed just a picture on the bottom right of what the capsule looks like seated in its holder in the vessel. Go on to the next slide, please.

Now I want to revisit what was discussed at the November 2019 ACRS meeting that EPRI participated in with my colleague Tim Hardin. I summarized the conclusions and recommendations from the final slide of that meeting on the right.

These conclusions have not changed from EPRI's perspective. If a future revision to the Reg Guide is implemented, E900-15 remains the preferred ETC model as of today. That's consistent with the

NRC's views as well.

It is understood that this, the target fluence is 6 times 10 to the 19th. Below that, the Reg Guide remains adequate for predicting embrittlement.

And I do went to focus then if 6 times 10 to the 19th is the level and we're worried again about PT limit curves, 10 CFR 50 Appendix G, the appropriate metric is the 1/4T fluence. So I felt it appropriate to determine when certain plant designs will see that fluence level at the 1/4T. So go on to the next slide, please.

This chart at the right shows the surface fluence value needed to generate a 1/4T and 3/4T fluence of 6 times 10 to the 19th using the attenuations formulas in the current Reg Guide.

As you can see, the various designs of PWR reactors in the US, the 2 and 3 loop WEC, B&W, the various 4 loops, and some of CEs all have different vessel thicknesses, ranging from a 62 inch thick vessel up to an 11.2. The 1/4T fluence of 6 times 10 to 19th necessary and the surface fluence necessary to hit that is listed under the 1/4T column.

So for instance, a WEC-4 loop with a B&W fabricated vessel needs a surface fluence of 9.99 E19 to hit a 1/4T fluence of 6 times 10 to the 19th. So I then looked at which plants have submitted for SLR and what their SLR fluence would be. And thus far, only one of the six PWRs would ever hit the necessary surface fluence to achieve a 1/4T fluence of 6 times 10 to the 19th.

And even that one plant, plant A, is going to take upwards of 65 EFPY (inaudible) are well into the SLR operating period, well into the future before that would occur.

You can also see from this chart a 3/4T, which is governing for the heat-up limitations, it seems like there would never be an issue. And in things that will never be an issue as well, in the bottom, BWR plants will never reach these fluence levels as well in any reasonable timeframe. The BWR SLR plant fluence is less than 5 times 10 to the 18th neutrons per centimeters squared at the surface.

So I just wanted to summarize when this could become an issue when you look at the 1/4T fluence and the surface fluence necessary to hit that value.

And that's all that I had for today. Thank you.

MS. OLMSTEAD: Thank you, Mr. Long. Now

Satira Labib from Duke Energy will make some presentation. And I'll ask the Operator to unmute Mr. Labib's line.

OPERATOR: Your line is now open.

MS. LABIB: Can you hear me?

MS. OLMSTEAD: Yes, we can.

MS. LABIB: Yes. I'm Satira Labib from Duke Energy, Reactor Vessel Integrity Engineer. And this is in regards to Slide 18 that mentioned Robinson Nuclear Plant. So in 2011, Robinson made a commitment to the NRC with withdraw their Capsule U when the capsule reached the 80 year peak fluence value which is 8E to the 19th. This commitment was made based on recommendations listed in what Elliot just discussed, MRP 326 to help the industry collect higher fluence data.

RNP still intends to abide by this commitment and withdraw Capsule U in 2024 when we reach the aforementioned fluence value. This will ensure that Robinson will have surveillance test data available to cover the predicted level of vessel fluence during the 80-year period and it should also be noted that the projected 60-year fluence is below the 6E to the 19th which is mentioned in this presentation. And the value above which the under prediction of embrittlement is considered to be found significant. That's my only comment.

Thank you.

MS. OLMSTEAD: Thank you very much, Ms. Labib. And now I understand Mr. Paul Gunter from Beyond Nuclear would like to make a presentation and I will ask the operator to unmute his line.

OPERATOR: Paul, your line is now open.

MR. GUNTER: Hello, can you hear me?

MS. OLMSTEAD: Yes, we can.

MR. GUNTER: Thank you. I don't really have a presentation per se, but you know, this is quite a complex subject here. And I'm participating mostly for my education and coming a little bit farther up on the issue.

I understand that per usual I can ask questions of the Nuclear Regulatory Commission, but I wanted to start to see if I could ask a question of EPRI. Is that permitted? If not, I could perhaps -- if EPRI can't answer, perhaps NRC could.

But on Slide 4 of EPRI's presentation, there's a bullet point there update to the evaluation includes, and I'm looking at the fourth point, their analysis of closed or to be closed plants. And I'm wondering with I could get a comment from either EPRI or from the Nuclear Regulatory Commission what analysis we're talking about there or if, in fact, there's another reference where I could go to get a better understanding of this update. Because I didn't hear the update in the presentation. So that's a question.

MR. RUDLAND: Paul, this is Dave Rudland. At this type of meeting, I believe we can ask questions to EPRI, but they don't need to respond. The questions should be directed towards the NRC.

And in fact, we have a section in a moment to do a question and answer session. So if you wanted to wait just a few seconds, we could do that. I wanted to make sure you were finished with any comments that you had or statements that you wanted to make before we moved into the question and answer section.

MR. GUNTER: Well, let me just say then to cut to the chase here to get to that question. You know, our main concern as an interested public advocate for public safety and environment protection, the subsequent license renewal proceedings are going ahead right now and I understand that you're saying that you're projecting loss of margin and offering reasonable assurance. But the fact that clearly, you have a performance inadequacy that has been identified and the -- but the public only has this shot at the subsequent license renewal window which is closing.

And so while there is a concern that was voiced in this meeting that the Agency has defined a performance issue by delaying these capsules and you're saying they've been delayed already 25 years, but we don't really know -- you're still working on your formula, so we don't really know how much longer this delay is going to be, but at the same time, the windows for the public due process are closing on age management programs which include reactor pressure vessel embrittlement and how your age management programs are falling behind at present.

So I'm raising that as a concern that you're providing yourself the luxury for the licensees to proceed through the review process. It's a little like paving the road as you travel, as you move right through the public process. So I'm raising that as a concern and that will conclude my comment.

MS. OLMSTEAD: Thank you very much, Mr. Gunter. We appreciate your statement.

And this brings us to the discussion and question and answer portion of this meeting. I'll ask Glenna to show Slide 37 again from the NRC slide deck.

And that gives us some suggestions of discussion topics for this session. And you can also ask other questions of course.

Our operator will now give you information on how to get into the queue for providing feedback and asking questions for today's topics and we will not be using the Webex chat or Q&A features, so please enter the queue if you'd like to speak during this meeting.

Operator?

OPERATOR: Thank you. We will now begin the question and answer session. If you would like to ask a question please press *1. Record your name clearly when prompted. To withdraw your request, please press *2.

MS. OLMSTEAD: And thank you very much. And in an effort to ensure that we hear from as many people as possible, we ask that participants limit their feedback and questions to about three to five minutes. After that, you can always reenter the queue and speak again as time permits.

And first, I'd like to turn to Mr. Scott for now to see if he received any questions from the public by email during today's presentation.

MR. BURNELL: Thank you, Joan. To this

point, I have not received any emails.

MS. OLMSTEAD: All right, well, thank you. And now I'd like to ask the operator to see if there's anyone in the phone queue that would like to ask a question.

Operator, first question, please.

OPERATOR: Thank you. Your first question comes from Paul Gunter. You're line is open and you may ask your question.

MR. GUNTER: Thank you. I'm just going to repeat the question that in EPRI's presentation they talk about how they're going to update their process for this and they outline an analysis of closed or to be closed plants and I'm wondering if EPRI could eliminate that or if the NRC might provide some comments. Thanks.

MR. HISER: Paul, this is Allen Hiser with NRC. I'm not quite certain what the bullet on that slide meant. I know that in many cases with plants that are shutting down, both we and the industry have looked at the surveillance capsules that are still available for the plant to see if there would be value in retrieving and testing those capsules. At this point, NRC has not found too much value in those capsules. I'm not sure if that's the full extent of the EPRI activity in this area or not.

MR. GUNTER: Well, I do know that -- can I comment and follow up?

MR. HISER: Sure.

MR. GUNTER: I do know that -- EPRI participated in a March 7th and 8th, 2017 workshop with the Nuclear Regulatory Commission and other industry and regulatory stakeholders that was looking at harvesting of decommissioning nuclear power stations with high priority on reactor pressure vessels. And I'm wondering where that subject has gone to, and if in fact, this is a reference to harvesting.

MR. HISER: I don't know if it is or not. I know that is one area that if there happened to be a plant that was decommissioning that we would be interested in obtaining specimens from the reactor pressure vessel. The problem is that the fluences on plants that would be decommissioning are not in the range that we have identified potential issues at present. If we had a vessel that had a fluence of 6 times 10 to the 19th, then we would probably be very interested in it. But there are no opportunities for that at this point.

MR. GUNTER: Would it also be able to

provide some insights on how neutron embrittlement is -- you know, the EMDA report referenced how neutron bombardment can actually penetrate a vessel wall and then bounce off the concrete on the other side and cause embrittlement to be working from the outer wall of the pressure vessel or welds, so that you could -- it just seems to me that there has been interest in harvesting samples for a whole host of insights to do with neutron embrittlement.

Would you not see any value for being able to capture actual data on how neutron embrittlement could be working its way by bouncing off the concrete and then embrittling from the outer side of the vessel inward?

MR. HISER: I know there were studies that had been done looking at through-wall embrittlement effects, and I would expect that some mechanism like you mentioned would provide evidence, would have provided evidence in those studies. I'm familiar with one from the 1980s because I was one of the lead reviewers or one of the lead technical staff on it. So I'm not sure that there would be much additional fruit that would be gained from pulling samples from decommissioned reactors to assess that at this point.

It may be that at some point in the future as plants that are decommissioning have high fluences on them, then at that point it may become more interesting for us. But I think at this point, those are some of the limitations.

MR. RUDLAND: This is Dave Rudland. In terms of what we're trying to do in this effort, especially with looking at the way the trend curves predict, I also have to agree with Allen, I don't see that it would add much to this particular study.

MS. OLMSTEAD: Well, thank you very much, everyone, for that discussion. And I'd like to go on next to our next person in the queue, please, operator?

OPERATOR: Thank you. And that's from Thomas Basso. Your line is open. You may ask your question.

MR. BASSO: Thank you. This is Thomas Basso. I'm with the Nuclear Energy Institute. I'm the Senior Director of Engineering and Risk. And it's kind of a comment and a question. So we do appreciate and support the overall approach from the holistic risk-informed analysis approach.

So my question probably to Dave Rudland is do you have enough information for doing this from an risk-informed approach or what else is needed to ensure from a risk-informed approach that we've come up with the appropriate way of looking at this?

Is there more -- you know, is there more work that needs to be done from the risk community or any outstanding concerns with the overall approach?

MR. RUDLAND: Thanks, Tom. Again, this is Dave Rudland. I don't think there's anything that's needed -- anything additional that's needed from the risk people. I think right now our biggest concern is plant-specific details. I think a lot of our -- some of our uncertainty, at least in analyses that we've done so far has been generically based and plant-specific information I think is the best way to try to focus that.

As I mentioned in the presentation, we don't really know how the plants are impacted at this point because we haven't done enough work to determine the individual plants are meeting the conditions that we're talking about. So I think that's where we need to focus our efforts, but I'm not -- I don't think getting more information from the risk folks would help us in this particular case.

MR. BASSO: In some of my earlier experience at a plant that I used to work at, I know that there's significant margin built into the operating procedures that address having adequate margin. But obviously, the more data we get, the more we can refine that margin, so appreciate the efforts, sir. Thank you.

MS. OLMSTEAD: All right, thank you very much. And operator, could we go to the next person in the queue?

OPERATOR: Thank you. And that's from Christopher Koehler. Your line is open. You may ask your question.

MR. KOEHLER: Hi, can you hear me?

MS. OLMSTEAD: Yes, we can.

MR. KOEHLER: My question is specifically related to -- I think it was the NRC's Slide 20 or so where you showed the Reg Guide embrittlement trend versus a best fit embrittlement trend and how a licensee might react to -- yes, that's the one.

And you stated that if the best fit was based on non-credible surveillance capsule data, that the Reg Guide directs the licensee to go back to the Reg Guide generic embrittlement trend which I think is inconsistent with how it's actually done in practice in which case, and this is based on the work shop slides that -- from post-Generic Letter 92-01 was it, where it indicated that if you have non-credible surveillance data, you should use the best fit chemistry factor from that data and then also use the full margin term on top of that. So I just wanted to confirm what I heard and what you intended when you said that.

MR. RUDLAND: This is Dave Rudland. Thanks for your comment. I do appreciate that. If you read the words of the Reg Guide, it doesn't make you use the non-credible chemistry factor. It says to go back to use the chemistry factor from -- that you derived from the chemistry. However, in many cases, the chemistry factor for the non-credible fit, I suppose, has been used. But the Reg Guide itself does not -- does not make -- does not force you or does not recommend that you use the non-credible chemistry factor.

MR. HISER: Chris, this is Allen Hiser. Just to amplify that, obviously the goal of the embrittlement or the surveillance program and use of embrittlement trend curve is to get the most accurate prediction that you have. So if you have non-credible data that are indicating a higher embrittlement than use of the chemistry factor from the tables in the Reg Guide, then we would hope that plants would use some more accurate representation.

So like Dave says, the Reg Guide doesn't say that you shall use it, but I think that clearly is within the engineering realm of wanting to provide the most accurate prediction.

So the workshop slides I think are still -- provide reasonable guidance on circumstances like that.

MR. KOEHLER: Thank you.

MS. OLMSTEAD: Thank you, too. And now I'll ask the operator for the next person in the queue.

OPERATOR: Certainly. And again just press *1 to ask a question. Our next question comes from Steven Richter. Your line is open. You may ask your question.

MR. RICHTER: Hello, this is Steve Richter, Energy Northwest. This question is for David Rudland. Going through your presentation, I didn't notice, perhaps I missed it, any discussion on heat affected zone material. Was there a reason it was omitted? Were you considering it bounded or just not for the purposes of this presentation? I saw the weld material, the base material, but not heat affected zone. Is that a concern?

MR. RUDLAND: I think the data that we

showed was the data that was given as part of the development of the ASTM E900 standard. Heat affected zone data I believe is not required through Appendix H any more.

MR. RICHTER: Okay. So that was the reason you left it out. That's fine. Thank you.

MR. RUDLAND: Yes.

OPERATOR: At this time, I'm showing no further questions.

MS. OLMSTEAD: All right, I'm going to give a couple minutes. Please press *1 if you'd like to get in the queue again, ask further questions, or make any other statements or provide input for us.

I do notice somebody has just joined the queue. Operator, can you introduce them, please?

OPERATOR: Jan, your line is open. You may ask your question.

MS. BOUDART: Thank you. I am Jan Boudart from Nuclear Energy Information Service. And I am looking at a paper and I was going to have it ready exactly when it was created, but it was kind of a long time ago. And it was also a Japanese paper. So -- oh, I don't have a date on this paper. I apologize. But it is created by Ino Hiromitsu and it is about a plant in Japan that there was never any consideration of it being reopened after the Fukushima accident. And the reason the Japanese did not consider restarting this plant was embrittlement or one of the reasons. And there is a graph in this paper showing the computer predictions of embrittlement and the actual capsules that were taken out of this plant. The name of the plant is Genkai 1.

And the last capsule that was taken out was so far above the predicted embrittlement that this is one of the things that influenced TEPCO in deciding not to reopen Genkai.

And so I just have a couple of comments about this that I would like to clear up. Number one, the Genkai graph is based on years, not on fluence. And I think that there has to be a justification for using fluence instead of years. And I wanted to point out that the 19th power is 10 times greater than the 18th power so that a huge amount of time will elapse from the time the fluence reaches the 18th power to the time it reaches the 19th power.

And I'm questioning whether that enormous increase in fluence would even occur in human history. I mean I don't know how long it takes for the fluence to reach these levels. And I was wondering if you could give us some examples of fluences that have been reached in real time, I mean like when did such and such a plant reach the 18th power? And when did such and such a plant reach the 17th power? And how long was the interval between reaching the 17th and the 18th? And how long does it take to get from one exponent to the next higher exponent especially when you're going from 18 to 19? Can someone estimate the amount of time it would take to go from the 18th to the 19th power? That's my question.

MR. HISER: This is Allen Hiser. I'll take the first crack at it. The fluences depend on the design of the reactor, how large the reactor vessel is, how much water is between the core and the vessel. So many BWR plants, which I'm assuming Genkai reactor may be, would be on the order of 10 to the 18th at 40 years or 60 years of operation. BWRs also have a variety of fluence levels. For example, just one that I'm familiar with, the Turkey Point plants, at about 60 years, the fluence is about 6 times 10 to the 19th. To go from 10 to the 18th to 10 to the 19th, there is no set number of years. It's just a factor of ten in the operation of the plant. So if a plant reached 10 to the 18th in 40 years, it would take them 400 years to get to get to 10 to the 19th.

MS. BOUDART: Say that last part again,

please, Mr. Hiser?

MR. HISER: It would be 10 times the operating period to go from 10 times 10 to the 18th to 10 times 10 to the 19th.

MS. BOUDART: And has Turkey Point been going for 60 years?

MR. HISER: They are about 50 years at this point.

MS. BOUDART: And do you have a fluence measure for them at 50 years?

MR. HISER: My guess is somewhere around 5 times 10 to the 19th.

MS. BOUDART: Five times 10 to the 19th? Oh, yes, because the coefficient is something -- what's the coefficient? I didn't remember that. Nine point something?

MR. HISER: Five times 10 to the 19th.

MS. BOUDART: Okay. Well, okay. So -- okay. And then I'm asking you to repeat again. You said Turkey Point is 5 times 10 to the 19th for a long time. How long -- I'm sorry to repeat this question. Maybe you answered it and I didn't pick it up.

How long does it take a reactor like at Turkey Point to go from 10 to the 18th to 10 to the 19th? I'm sorry, I know you said this, but I missed it.

MR. HISER: It would be -- let's see. It probably was about year one that they were about 10 times 10 to the 18th, approximately. Then about year 10 when they would have been about 1 times 10 to the 19th. And these are guesstimates from recollection.

MS. BOUDART: Certainly, there were capsules that were taken out -- oh, that would be a different measurement though, the measurement of brittleness, but not a measurement of fluence.

Okay, and then can you explain why you have decided to go with fluence instead of time?

MR. HISER: Fluence is a measure of the number of neutrons that have hit the reactor vessel and so that correlates with the damage. If the reactor is shut down for outages, it accumulates no additional fluence. So it doesn't --

MS. BOUDART: Right.

MR. HISER: There's no real strong correlation with time. It's really how much time the plant operators.

MS. BOUDART: Okay. I appreciate your answer. Thank you so much.

MR. HISER: Okay.

MS. OLMSTEAD: And thank you very much for your statement, Ms. Boudart.

And now I don't see anyone else in the queue. I'll give people a few more minutes. Please press *1 if you'd like to get in the queue and make a statement or ask any questions.

Operator, do we have someone else in the queue?

OPERATOR: We do. Michael Guthrie, your line is open. You may ask your question.

MR. GUTHRIE: Hello. This is Michael Guthrie with Dominion Energy. I have a question regarding the value of 6 times 10 to the 19th that's in the NRC presentation. Are you referring to inside surface fluence or are you talking about 1/4 T fluence as Elliot Long was referring to?

MR. RUDLAND: This is Dave Rudland. The number that we were referring to was just the fluence level in which the under prediction of the embrittlement trend curve becomes statistically significant, whether it occurs -- no matter where it occurs it's throughout the wall. We were just looking at the point at which the prediction becomes non-conservative. So if you're looking at PT curves, it 1/4 T. If you're looking at PTS, it's ID surface.

MR. GUTHRIE: Thank you. That clears it

up.

MS. OLMSTEAD: And thank you. Operator, is there anyone else in the queue?

OPERATOR: At this time, I'm showing no further questions.

MS. OLMSTEAD: I'll give a couple more minutes. Please press *1 if you'd like to get in the queue to ask a question or make a statement. And if we don't have anyone else showing up, I'll probably start closing the meeting.

Operator, do we have anyone else in the queue?

OPERATOR: At this time, I'm showing no further questions.

MS. OLMSTEAD: All right, I'm just checking on something and -- all right, it looks like we don't have anyone else in the queue.

So please, Glenna, can you put up NRC Slide 39?

All right, and as you can see on this slide, to find more information about this meeting, you can go to this website, regulations.gov and look at the docket number, NRC-2021-0174. Now the NRC will post today's meeting summary and transcript within 30 days from today on the regulations.gov site.

And please note that while the regulations.gov's standard template mentions comments, we will not be taking comments for this project at this website.

Slide 40, please. I'd like to remind everyone to fill out your meeting feedback forms located at the NRC's recently held public meetings webpage for this meeting's announcements. Your input helps us improve future NRC public meetings.

Next slide, please. And these are some contacts if you want to contact these people for more information about this topic.

And thank you all for your attendance at today's meeting. We very much appreciate your time and feedback and we will carefully consider today's discussion and look forward to engaging more with you in the coming months. Thank you.

And that will end our meeting for today.

(Whereupon, the above-entitled matter went off the record at 2:48 p.m.)