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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON MATERIALS, METALLURGY AND REACTOR FUELS

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WEDNESDAY

MARCH 4, 2009

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ROCKVILLE, MARYLAND

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The Subcommittee convened in Room O1G16 in the Headquarters of the Nuclear Regulatory Commission, One White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 1:30 p.m., William Shack, Chairman, presiding.

SUBCOMMITTEE MEMBERS PRESENT:

WILLIAM SHACK, Chairman
J. SAM ARMIJO
DENNIS C. BLEY
DANA A. POWERS
JOHN D. SIEBER
SANJOY BANERJEE

DESIGNATED FEDERAL OFFICIAL:

MICHAEL L. BENSON

NRC STAFF PRESENT:

MARGARET "MEG" A. AUDRAIN, NRR

STEPHEN C. DINSMORE, NRR

JENNIFER "JEN" M. GALL, NRR

MARK ERICKSON KIRK, RES

A. JASON LISING, NRR

MATTHEW A. MITCHELL, NRR

GEARY S. MIZUNO, OGC

THEODORE "TED" R. QUAY, NRR

TIMOTHY "TIM" A. REED, NRR

STUART A. RICHARDS, RES

VERONICA M. RODRIGUEZ, NRR

DANIEL "DAN" WICHERITZ, NRR

JACOB "JAKE" ZIMMERMAN, NRR

ALSO PRESENT:

WILLIAM ARCIERI, ISL,

INFORMATION SYSTEM LABORATORIES

STEPHEN BYRNE, WESTINGHOUSE

J. BRIAN HALL, AREVA

KEVIN HOLTHAUS, OPPD,

OMAHA PUBLIC POWER DISTRICT

JACK SPANNER, EPRI,

ELECTRIC POWER RESEARCH INSTITUTE

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

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

(Time not noted.)

CHAIRMAN SHACK: -- published in The Federal Register. We have received no written statements or requests for time to make oral statements from members of the public regarding today's meeting. A transcript of the meeting is being recorded. Therefore, we request that participants in this meeting use the microphones located throughout the meeting room when addressing the subcommittee. The participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard.

PARTICIPANT: We have no court reporter.

CHAIRMAN SHACK: No. That is another little glitch in the system.

MEMBER BLEY: Mr. Chairman, I don't know if this is the right time, I need to remind you that I have a conflict with respect to the Human Reliability Analysis and to support the PRA behind it.

CHAIRMAN SHACK: Correct. And again, just as a little background, as we probably all know, Pressurized Thermal Shock, PTS, arises from the embrittlement that occurs when a reactor vessel is subjected to neutron irradiation. In particular, the concern arises from the increase in the ductile to brittle transition temperature and events during which injection of cold water into the vessel gives rise to high thermal stresses on the surface of the vessel; vessels and welds containing a distribution of flaws. If the thermal stresses are high enough and the vessel embrittlement high enough, these cracks can become to grow and in some cases penetrate through wall.

To understand this behavior, we need to consider the likelihood of sequences leading to the injection into the vessel, the thermal hydraulics of that process, in particular the temperature of the fluid and the heat transfer from the fluid to the vessel wall. The likelihood of cracking has to be computed from a Probabilistic Fracture Mechanics Code that takes into account the thermal hydraulic challenge, the embrittlement of the vessel and the nature of the flaw distribution in the vessel.

The Office of Research has carried out an extensive program considering the problem in detail for three plants. The results indicate that the current regulations governing PTS are overly conservative and impose an unnecessary regulatory burden. NRR is developing a new PTS rule incorporating insights from the research work. A major issue in developing the rule is how to ensure that the results from the detailed study of three plants are applicable to a broader range of plants. Currently, the primary concern is that the individual plant be able to calculate the degree of embrittlement in its vessel and undertake to demonstrate that the flaw distribution in this vessel is comparable to that use in the detailed studies.

One of the issues raised at our last subcommittee meeting was whether it should also be necessary to demonstrate that the likelihood and severity of events that produce PTS challenges for a specific plant is comparable to those from the three plants in the detailed study. This question of the generalization of the results is the measure technical focus of today's presentations.

We will now proceed with the meetings and I will call upon Ms. Rodriguez of the Office of Nuclear Reactor Regulation to begin.

MS. RODRIGUEZ: I am going to provide the opening remarks for the staff.

MR. QUAY: Good afternoon. My name is Ted Quay. I am Deputy Director of the Division of Policy and Rulemaking in the Office of Nuclear Reactor

Regulation. This afternoon the staff is here to discuss the rulemaking associated with a new alternative PTS rule 50.61a. This rule will benefit licensees who may not be able to comply with the current requirements of the PTS rule through their licensed operating period. The Rule was made possible through the efforts of several offices, including Research, NRR, NRO, ODC, OIS and ADMIN. The alternative rule is expected to facilitate the continued operation of eight to twelve PWRs through their 60 year license operating lifetime.

And with that, I would like to turn it over to Veronica Rodriguez, the NRR Project Manager on 50.61a.

MS. RODRIGUEZ: Thank you, Ted. Good afternoon everyone, I am Veronica Rodriguez and I am the lead project manager for these rulemaking actions.

As Ted mentioned, the rulemaking that we are going to discuss today represents the hard work and dedication of many, many years from many, many staff members throughout the agency. We have materials engineers, thermal hydraulic experts, PRA experts, lawyers, branch chiefs, project managers. You name it, probably we have had it.

So, I would like to recognize the

participation of the following working group members. The active members are Barry Elliot, Matt Mitchell, Steve Dinsmore, Lambros Lois from NRR, Mark EricksonKirk and Bob Hardies from Research, Nihar Ray from NRO, and Geary Mizuno from OGC.

I would also like to recognize the assistant from the rulemaking team from ADMIN, the information collection team from OIS and the presence of Mr. Bill Arcieri from ISL, who is one of the contractors who assisted in the development of the technical bases.

On a funny note, I would like to recognize Pete the Penguin is the mascot of the group. The team asked me to bring him along. It might be his last public appearance. So, it has been with the --

MR. QUAY: Hopefully.

MS. RODRIGUEZ: -- group for many, many years, and there are many, many stories involving the penguin and so, he is here with us today and hopefully he will sit in with further meetings.

On a more serious note, today we are going to concentrate on three main topics. First, we will talk about the final rule language, 50.61a, then public comments and NRC responses, and finally, we will talk about the generalization study.

With that, I am going to ask Matt to provide you an overview of the alternate PTS rule.

MR. MITCHELL: Thank you, Veronica. I am Matthew Mitchell, Chief of NRR's Vessels and Internals Integrity Branch.

I would like to start by thanking the subcommittee for having us here today to discuss the final version of the 10 C.F.R. 50.61 rule. I would note that distilling down a rule as complex as 50.61a is and discussing our resolution of the public comments in the hour and a half that we have on the agenda is, I think, quite a challenging task. The presentation that has been developed to go over those two particular parts of the agenda has been made at a reasonably high level. But we are prepared to go into more detail, based upon specific interests of members of the committee.

So with that, let me get started with my overview slide on the 10 C.F.R. 50.61a rule. As I am sure the committee members noted in reviewing through the rulemaking package, 10 C.F.R. 50.61 alpha has been intentionally structured to be very similar to 10 C.F.R. 50.61. We did have numerous choices in terms of ways we could have changed the structure of the rule. However, we felt that the similarity between the two rules should be emphasized to help facilitate implementation and understanding of the rule by both industry and NRC staff. Significant or notable difference between the two rules, however, reflect critical features that are different in 50.61 alpha versus 50.61.

UNIDENTIFIED SPEAKER: (Inaudible.)

MR. MITCHELL: No, not specifically. And if you are asking did we do a detailed assessment, no, it was more of a, if you will, a regulatory judgment call, if I can use it in that parlance to say that in just observing what we believe to be the most effective structure in terms of getting and facilitating understanding, the initial decision to make the rule more similar to 50.61, given that there were going to be inherently many features there were going to be similar to begin with, it was just wise to.

UNIDENTIFIED SPEAKER: (Inaudible.)

MR. MITCHELL: Well, we don't think that there will actually be confusion between the two rules. We think it will be clear, based upon the steps that are involved in the rule in terms of a licensee making a cognizant decision to enter 50.61 alpha, to get staff approval to utilize 50.61 alpha as part of a licensing action, that they are --

UNIDENTIFIED SPEAKER: (Inaudible.)

MR. MITCHELL: No, I'm sorry. 50.61a, 50.61 alpha, I am using the terms interchangeably. But we don't anticipate that there will be confusion with plants' licensee bases given the steps that we have put in place in the rule to have a positive reinforcement, positive decision-making in terms of where a licensee is located and which rule they are conforming to.

So for the remainder of this presentation, I intend to step through the various sections of the rule to provide a general overview of the major features of each section and then let the questions take us where they will, in terms of drilling down in the various section. Next slide. Thank you.

Section (a) of the 10 C.F.R. 50.61 alpha rule I hope is a fairly non-controversial section. This merely where we have defined terms that we are using in the rule. Again, where applicable, we have maintained the definitions that are used in 50.61. In one particular case, that of the definition of ASME Code, we have broadened the definition to include Section XI specifically because there aspects of 50.61 alpha where in-service inspection related topics are incorporated, which is not a common feature of 50.61.

And in addition, of course, terms that are specific to 50.61 alpha have been added and defined as appropriate for this particular rule.

Section (b) of the rule addresses the rule's applicability and this is where we begin to find some unique characteristics of 50.61 alpha. In particular, 50.61 alpha has been, its applicability has been limited to the existing fleet of pressurized water reactors and technologically similar units. And by that, I can provide some examples. Watts Bar Unit 2, the Zion units, which we have been told there has been some discussion about potentially restarting Zion units. Units of that type would also be covered inherently under 50.61 alpha because they are accepted to be systematically and phenomenonologically (phonetic) to the units that were analyzed as part of the technical basis for the rule.

Specifically, other more advanced designs, for example, AP 1000 have not been specifically analyzed and demonstrated to be consistent with the technical basis upon which the rule has been developed. So, in part based upon a public comment that we received during the public comment process, as well as the staff's own observations, it was deemed to be prudent at this point to not make 50.61 alpha inclusive of those particular reactor designs. However, we would note that certainly through the 50.12 exemption process, it would be possible for future licensees to take advantage of 50.61 alpha, if they demonstrated that in fact the rule was also applicable to their units.

I will say in terms of good news, I think no one certainly on the staff would expect that new reactors to be constructed in the future would even need to make use of 50.61 alpha, that being able to operate within the bounds of 50.61 is sort of the clear expectation, given the advancements in reactor pressure vessel design and fabrication that have occurred over the years.

In section (c) of the rule, we have defined the steps to request approval for a licensee's use of 50.61 alpha. In particular, the rule requires that a licensee wishing to implement 50.61 alpha must make a license amendment application in accordance with 10 C.F.R. 50.90 and be granted staff approval to utilize 50.61 alpha.

The staff deemed that this was in fact an appropriate step, in large part, due to both the significance of the issue, that of protecting the reactor vessel from brittle failure, as well as the complexity of the rule. In particular, steps related to the demonstration that a particular plant's flaw distribution is consistent with the flaw distribution that was used in the technical basis.

We would also note that in terms of the application, there have been certain timing provisions placed into 50.61 alpha to make it consistent with the expectations that are already documented in 50.61. Specifically, use of 50.61 alpha is expected to be requested three years prior to -- three years or more prior to a facility being projected to exceed the screening criteria in 50.61. So there is a synergy between the two rules in that regard, that we believe the criteria are consistent.

Specific information that is required to be submitted in the licensee's initial request for approval to use 50.61 alpha includes material property values compared to the rule's screening criteria. This is fundamentally similar to what we find in 50.61 where plants are asked to calculate RTPS values and demonstrate that they meet the screening criteria of the current rule.

We have changed the nomenclature to refer to the new material property value as RT_{MAX}. In this case, RT_{MAX} plate, RT_{MAX} axial weld, circumferential weld, they are forging to try to avoid confusion specifically with RT_{PTS}.

UNIDENTIFIED SPEAKER: (Inaudible.)

MR. MITCHELL: That is correct.

UNIDENTIFIED SPEAKER: (Inaudible.)

MR. MITCHELL: Certainly. A facility could elect for their own purposes to enter 50.61 alpha, even if they were projected to meet 50.61. I am not sure I necessarily would anticipate a licensee choosing that but it would certainly be an option.

Okay, now I am going to come back a little bit later when I talk about section (f) and go into a little more detail about the specific screening material that are incorporated into 50.61 alpha. So, I just mentioned here that specifically the values have to be submitted, including consideration of reactor vessel surveillance data and how that data might effect a licensee's calculation of their RT_{MAX} values for the various materials of their reactor vessel.

In addition, as part of the application, the licensee must provide an evaluation of their reactor vessel in-service inspection data to demonstration consistency with the technical basis of the rule. And this goes to a further discussion that we will have when I get to Section (e) about the requirements for the flaw distribution check that are mandated by the rule and what licensee's must demonstrate in that regard. So this would be based upon a licensee having existing in-service inspection data from prior examinations, which would allow them to make this determination in accordance with Section (e) and this demonstration as part of the application.

Section (d) of the rule then goes on to articulate what we call subsequent requirements. And this is the looking forward piece of the rule. And it stipulates that licensees must provide updated RT_{MAX-X} values to ensure that they continue to comply with the screening criteria. And one could imagine that a licensee's projected RT_{MAX} values could change, just like RT_{PTS} values change due to acquiring additional reactor vessel surveillance data, updated fluence evaluations, etcetera. There may be reasons why those values change, those projected values change. The expectation is the licensee will make that information available to the staff.

Perhaps more importantly, the second part of section (d) relates to future in-service inspection and data gathered as part of the licensee's ASME Code

In-Service Inspection Program. Section (d) would require that licensees consistent with what information that was provided in the initial application evaluate future in-service inspection data to continue to demonstrate that the law distribution in their vessel complies with the flaw distribution tables provided in the rule for acceptability in applying this particular regulation.

The staff has deemed that this is an appropriate step in large part because we are sensitive to the fact that one of the major changes or one of the major technical differences between the foundation for 50.61 and 50.61 alpha was the incorporation of a considerably more realistic flaw distribution in the Probabilistic Fracture Mechanics Calculations that are in the technical basis for 50.61 alpha.

In consistency with the NRC's approach to risk-informed rulemaking, and that is effectively what 50.61 alpha represents, we felt it to be warranted to continue to monitor that particular assumption going forward and that licensees should be required to demonstrate that there is no new information that has been gained about their vessel which would suggest that those assumptions are no longer appropriate for their plant-specific case. So to stay on top of that particular issue -- and for Dr. Armijo, we are on slide nine.

MR. ARMIJO: Sorry for being late.

MR. MITCHELL: No, that's fine. That seemed to be an appropriate and worthwhile step to take to keep up with that particular aspect.

In addition --

CHAIRMAN SHACK: Is there any augmented schedule or they are going to continue on their regular ASME inspection program?

MR. MITCHELL: Currently, licensees are required to perform ASME Code inspections in accordance with the ASME interval. There have been activities within the industry to, based off of the same technical basis that supports the PTS rulemaking, to request an extension of inspection intervals for their reactor vessel, in large part because there has been no demonstrated flaw growth or flaw changes to existing pre-service flaw distributions.

But however, as part of that activity which has been going on on a separate track, one of the expectations for licensees that are asking to take advantage of that particular provision is that they would also do a flaw distribution check in accordance with the provision stipulated in 50.61 alpha because, at the root, that concept that there is a technologically justifiable position that would allow for the extension of the interval, it comes back to the same technical basis as the PTS rulemaking, we felt that it was important to roll that over for licensees seeking that particular alternative.

So, the answer is, for most licensees, as of now, yes, they would be inspecting the vessel in ten-year intervals. However, some licensees may request to extend that interval out to as much as 20 years, based upon work that has been done by the industry off of the PTS technical basis work.

CHAIRMAN SHACK: How many cycles of inspection have we been through since the performance demonstration? I'm not sure how many years of qualified inspections we really have, compared to the number of years we have been inspecting.

MR. MITCHELL: I can't answer that question, specifically. I believe that every vessel has been through at least one PDI-qualified examination.

CHAIRMAN SHACK: It is a little tough to trend that.

MR. MITCHELL: No, agreed. I guess the

other thing that I would note is that to the best of my knowledge, however, the inspection of this particular system, low alloy steel reactor vessels has not been, certainly the most challenging configuration to inspect from an NDE perspective. It is --

CHAIRMAN SHACK: Even for the flaw sizes of interest here?

MR. MITCHELL: Not all of the flaw sizes of interest in this particular rulemaking have been called out as flaw sizes of interest from a code inspection activity perspective. And that is sort of part of the enhancement that we will be asking for licensees to do as part of implementing this rule. That being that they would need to do some more defined post-processing of their ISI inspection data to specifically look for indications which may fall below the normal ASME code threshold of interest from a code inspection perspective.

So yes, what we are doing in this rule has the licensees examine their data at a lower level, looking for indications that they might otherwise not necessarily call out, because they would be smaller than those of interest.

CHAIRMAN SHACK: Do you have research work underway to verify the assumptions that they are going to make as they do this, post processing?

MR. MITCHELL: We have had research engagement on the question of whether or not this request that we are making, this requirement to analyze the data is feasible. And my understanding is from our office of research, particularly in consultation with the NDE Center at EPRI, as well as in discussions with the industry in general is that in fact it is possible to take ASME Code, PVI qualified data and extract the kind of information that we are asking for in a reliable fashion.

The one caveat that we have introduced into the rule has been the notion that NDE uncertainty, of course, could play a relatively large role when you are talking about looking for relatively small flaws. So, as part of the rule, we have included an allowance that a licensee could come in and present a technical justification of what the uncertainty is that was associated with their inspection as part of their demonstration that they comply with the rule. So we have introduced that allowance.

Now we would think, of course, that when you are talking about these very, very small flaws that we are asking licensees to look at, that the general trend, of course, in NDE would be to oversize the flaw. It is hard to undersize something that is that small to begin with. So the standard or just the unrefined ultrasonic data might be expected to be a conservative representation, just due to the general bias for oversizing. But if a licensee was unable to demonstrate just from the data alone that they met the requirements of the rule, they could come in and address the topic of NDE uncertainty as part of their application.

Sorry, Mr. Sieber, did you also have a question?

MR. SIEBER: Yes. (Inaudible.)

MR. MITCHELL: That is our understanding. Yes, in talking again with those folks in the office of research who run our in-service inspection programs, their interactions with EPRI's NDE center, which is a large participate in the performance demonstration initiative, that it is believed that the state of ISI is capable of reliably providing data which will help us or help licensees demonstrate that they do comply with this rule.

CHAIRMAN SHACK: Do you expect to see a NUREG CR or a topical report to demonstrate this and document it?

MR. MITCHELL: We have not asked for such from the Office of Research. That would be a takeaway for us to get back and look into whether that data can be readily made available.

UNIDENTIFIED SPEAKER: Has anyone ever done this, actually post-processing of these (inaudible) come to a conclusion that they are real?

CHAIRMAN SHACK: I'm sure they can do the post-processing.

UNIDENTIFIED SPEAKER: Yes, but the latter part, you know, said this is real and if I did another inspection, I would likely find them again, even if a repeat. We are working with something that is actually real and has a benefit.

MR. MITCHELL: I will ask Dr. Kirk if he would like to speak to that from Research's perspective.

MR. KIRK: I was actually going to throw it back to you because I think the best demonstration of this isn't it the Calvert Cliffs' application?

MR. MITCHELL: Yes, Calvert Cliffs, as we were discussing earlier about the question of going from ten years to twenty years in the ISI interval, Calvert Cliffs has made a submittal to take advantage of that. And they in fact did demonstrate and look at the data that they had already acquired through a PDI-qualified examination to show what they were able to identify.

Now the question always, of course, comes down to the data versus what is actually there. A lot of work, of course, was done in the technical basis to look at samples from the PV-RUF vessel as well as the Shoreham vessel to look at least laboratory --

CHAIRMAN SHACK: Yes, but those inspection techniques are different than what we expect to find.

MR. MITCHELL: Agreed. Agreed. I cannot say offhand that we have done more than what I indicated in terms of inquiring with the PDI Center and working again with the folks in Research who are monitoring the ISI programs to follow-up on the viability of what we are requesting. But to date, we believe it is certainly viable and can provide accurate data.

MR. KIRK: If I could just interact, I mean, interject. The question you are asking are certainly well very germane and also very current in terms of research's interaction with our colleagues at the EPRI NDE Center. And so like Matt said, I think this is a takeaway, something that we should be adopting as an ongoing activity. Certainly I think, just speaking personally, if I didn't have some confidence in this, I wouldn't have advocated putting it in the rule. But to say that all of the answers are settled and it has been fully demonstrated, clearly the answer is not yet and --

MR. MITCHELL: No, I think --

MR. KIRK: -- ongoing work is needed.

MR. MITCHELL: -- it will come down to what uncertainties we assign to these results.

MR. KIRK: Exactly. Exactly. As Matt indicated, the information that we now have available indicates that if you had to bet and you wanted to bet on the more sure side, would be that if you say there is an indication there that is an eighth of an inch, odds are it is probably a quarter of an inch. So, if we are making an error, we believe that ewe are making it towards the conservative side but certainly collecting more information and more definitive information in terms of using real field techniques to inspect things and then chopping them up afterwards so there is an unequivocal measurement would be a good thing to do.

MR. MITCHELL: Or to benchmark them against techniques like you use for the PF-RUFF.

MR. KIRK: Yes, yes, there are many ways

to do it.

MR. MITCHELL: There are various ways to slice it but clearly you need to somehow to come to some degree of confidence in these results. And we really haven't seen a demonstration of that. I mean, you can write the rule. That is fine. But to accept an application --

MR. KIRK: The other thing, just to bring in the Calvert Cliffs application that was striking to us is that when you look at the population of flaws that had been assumed in our Probabilistic Fracture Mechanics Calculations, just in terms of, forget about sizes for a minute and talk about numbers, there are thousands upon thousands of flaws that are seeded into each of these mathematically simulated vessels; whereas, using the most current state-of-the-art techniques on the Calvert Cliffs vessel, they found I think it was seven or eight.

And admittedly, it is only one data point so one shouldn't get too giddy. But that is very reassuring to me that we have taken a realistic approach but also in comparison with the reality that we are trying to regulate, it appears to be very conservative.

CHAIRMAN SHACK: I'm not sure it gives me the same degree of comfort. I mean, was there something non-prototypical about the welds that you were looking at or does that indicate that these methods aren't seeing the same thing that the SAF techniques we are seeing on the other welds.

MR. KIRK: Reasonable questions.

CHAIRMAN SHACK: It just seems to me an issue that needs addressing.

MR. KIRK: Yes. I think those are important and good questions and ones that get to the NDE and the reality of what is there. I guess I was expressing confidence in terms of the underlying technical basis that is driven to the reference temperature limits. And that if we assume thousands of flaws are there and in reality it is more like tens or even hundreds, clearly the reference temperature limits in our table have then a pretty good degree conservatism in them.

CHAIRMAN SHACK: Yes, I --

MR. KIRK: But yes, your questions are relevant from an NDE viewpoint.

UNIDENTIFIED SPEAKER: From the standpoint of flaws, it is not the numbers so much, it is the size. And I would think the size is harder to estimate.

MR. KIRK: Well both are really important and I don't want to understate size but number is important, too, because the larger the density is, the more likely one of those flaws is going to show up in a location of higher fluence and larger transition temperature shift. When you have got only ten flaws seated around large numbers of square meters of surface, the odds of a confluence of bad events go down very rapidly but size is important, too, for sure.

UNIDENTIFIED SPEAKER: Okay.

MR. MITCHELL: Yes, I think clearly the committee's comments certainly do speak to question of eventual implementation of the rule. I am not sure that there is necessarily anything we would do different about how we write, how we have written the rule in terms of trying to put this expectation in place but when it comes to implementation, that is correct. We should think about that further when we look at people's applications as they come in.

So, also in section (d), we identified basically the same list of additional actions that a licensee might take if they are projected to exceed the screening criteria in 50.61 alpha, just as in 50.61. In particular, flux reduction, plant modifications such as heating of ECCS injection water has been one option considered, advanced analyses, or thermal annealing in accordance with 50.66 are the general options that are available in both rules.

Okay, we have already talked some about section (e) but specifically this may be the most significant difference between 50.61 alpha and 50.61. It defines a specific detailed evaluation of plant-specific flaw distribution for the purpose of ensuring consistency with the technical basis for the rule.

Fundamentally, the staff based the expectation off of data to be acquired through ASME Code qualified inspection techniques. In particular, those complying with Section XI, Appendix 8, Supplements 4 and 6, with as we alluded to previously, sort of enhanced post-processing to specifically call out and look for smaller indications, which may be relevant to the rule but might not be specifically called out from a typical ASME Code evaluation.

And we have built in an allowance to have licensees potentially adjust their NDE results based upon a demonstration of their knowledge of the uncertainty associated with their examination and are requiring that the licensees make comparison to acceptance criteria in the rule to tabulated values in

Tables 2 and 3, as well as ASME Code criteria. There is a particular interest in the rule, I think you will see, in terms of near-surface defects that may be identified through NDE in verifying that those defects in fact do not open to the surface so that they are not in alignment with any type of cladding defect, which would make a surface-breaking flaw as opposed to an imbedded flaw. That is another feature of this particular section, too, because those of course are considerably more detrimental than imbedded flaws, which have lower driving forces.

MR. MIZUNO: Just in my attempt to be a lawyer, you might look at that language in that thing where it tells you to look at the total length weld that you have inspected and divide by a thousand inches, it probably tells them to get the length in inches before you divide by the thousand inches.

MR. MITCHELL: Okay.

UNIDENTIFIED SPEAKER: Instead of microns?

(Laughter).

UNIDENTIFIED SPEAKER: Well, I was thinking meters, which would help my distribution a lot.

MR. MITCHELL: Consistency would be a good thing.

Section (e) also requires that if the licensee's evaluation of their flaw distribution fails to meet the requirements in the rule, that an analysis of the RPV be performed to demonstrate that the vessel has acceptable through-wall cracking frequency. Now the nature of this analysis may vary, depending upon the case-specific scenario.

A couple different scenarios that I believe we have discussed in the statements of consideration are if you were, for example, to have one flaw that exceeds the tabulated values, a specific defined look at that flaw if it were in, let's say, a very low embrittlement region could be sufficient to demonstrate that that flaw alone does not indicate an excessive through-wall cracking frequency.

Alternatively, if a licensee had a generically greater than allowable flaw distribution across all of the identified bins, it might require a plant-specific Probabilistic Fracture Mechanics analysis to do a more holistic evaluation to demonstrate that they still have acceptable levels of through-wall cracking frequency.

So there is some flexibility, at least. We didn't prescribe exactly what must be done because it really should come up on a case specific basis what an appropriate demonstration would be.

UNIDENTIFIED SPEAKER: But the number would still be ten to the minus six. You would still have to meet that --

MR. MITCHELL: That's correct.

UNIDENTIFIED SPEAKER: -- no matter what analysis you did. If it came out to be two times ten to the minus six, you are out of luck.

MR. MITCHELL: That would be the figure of merit. Yes, one times ten to the minus six.

In section (f) --

CHAIRMAN SHACK: Are you going to write a NUREG guide?

MR. MITCHELL: We have had discussions --

CHAIRMAN SHACK: The other one was so successful.

MR. MITCHELL: We certainly have had discussions with the Office Research about developing an implementation Reg guide for several aspects of --

CHAIRMAN SHACK: I was thinking particularly of the analysis that you might have to do.

MR. MITCHELL: The flaw distribution analysis evaluation of surveillance data, there are aspects of this rule that might benefit certainly from additional guidance and that is certainly under consideration. We think, though that the rule can be successfully implemented even in lieu of that guidance. So, we are not placing a requirement on ourselves to get the guidance out, necessarily, in a time frame consistent with getting the rule on the street. But we are looking at the possibility of what could benefit from such guidance.

My next slide, which I have suggested is a discussion of section (f) should probably really be sections (f) and (g), since (g) just contains the equations used for doing many of the calculations. So, I will, I think questions regarding either of those would be relevant here. But section (f) specifically gives the methodology for calculating RT_{MAX-X} values similar to the calculation of RT_{PTS} values in 10 C.F.R. 50.61.

Some of the notable difference in the calculation of RT_{MAX-X} and in particular the first bullet that RT_{MAX-X} does not include a "margin" term that we are so used to in the calculation of RT_{PTS}. RT_{MAX-X} is a calculation of effectively a mean property. A mean material reference temperature. That observation makes a one-to-one comparison of the screening criteria in 50.61 versus the screening criteria in 50.61 alpha, sort of an apples to oranges comparison.

A more, although not precise, a better comparison if one wanted to compare the two rules would be to imagine that the screening criteria in 50.61 would be to 10 in a mean sense for axial welds and plates or 240 for circumferential welds. And that would give you a better numerical comparison. Although again, that would not be necessarily exact either, but it is closer than looking at 270 and 300 in that regard.

Also, specifically for welds, there must be a consideration of the associated plate and forging properties. So, you see the MAX function in the calculation for the RT_{MAX} value, for example, axial welds or circumferential welds, keeping in mind that a flaw specifically associated with a weld could take advantage of a nearby embrittled plate or forging and propagate through the plate instead of through the weld material, if the weld material were actually tougher. So we require that for welds, one looks at both properties and takes the maximum of those two as the appropriate reference temperature.

And finally, RT_{MAX} requires the use of the updated embrittlement models and surveillance data evaluations prescribed in the rule.

UNIDENTIFIED SPEAKER: Could you explain that a little bit more, how that analysis for welds and taking into account the plates or forgings adjacent to the weld site? Exactly what would somebody do, come up with three different RT_{MAX} numbers and pick the worst one?

MR. MITCHELL: Dr. Kirk can explain this far better than I can. So, I am going to let Mark do it.

MR. KIRK: I will try to be brief. So, for just take as an example and axial weld that might have on either side of it two plates on it with two different chemistry values. So, the flaws that we have simulated are lack of fusion defects so they lie notionally between the weld and the plate. So, first off, you find, and this is a feature that Matt didn't reflect but is important, an important difference from the existing rule, is along that axial weld line, you find the fluence at that azimuthal location, which might not be and in fact in many cases is not the max fluence over the whole ID of the vessel. So that is an important difference.

So, you find the fluence and then you just calculate the transition temperature shift for the weld and for the two adjacent plates at that fluence. So now you have got three values, if you will.

UNIDENTIFIED SPEAKER: Now the weld is on one side -- there are flaws on one side of the weld --

MR. KIRK: Well we don't --

UNIDENTIFIED SPEAKER -- next to one plate but far from the other plate.

MR. KIRK: Yes but in the implementation, I mean in favor, it would make that distinction. In the implementation, we don't.

So anyway, for a given weld location you will have, for a given weld, you will have three different values that you will compare. You will compare the unirradiated value plus the shift for plate A, the unirradiated plus the shift for the weld and the unirradiated plus the shift for plate B. You will pick the highest of all of those and now you will -- okay, and then you will write that number down and then you will go around the whole vessel and do the same thing for each and every axial weld. You will write all of those numbers down and you will pick the highest of all of them.

And the notion is and we took this same approach in deriving the reference temperature limits from the favor results. And so if you said well if you have got thousands of flaws seated all around the vessel, where are the ones that are going to get you? Well they are probably going to be the ones that somehow unfortunately landed in the most embrittled location. And what we found out is that when we made plots of the through-wall cracking frequency due to flaws in axial welds and used this metric that I have described of finding, essentially the most embrittled location along any axial weld seam, we got a very good correlation of the results. So essentially, we were blaming that part of the failure frequency we felt on the right thing.

So, it is essentially a big tabular comparison that you have to do and you calculate up a lot of numbers in application and then you pick the biggest.

MR. MITCHELL: Thank you, Mark. And then with regard to the embrittlement models, we have prescribed specific models to be used for the calculation of the shift in embrittlement due to irradiation. The models that we have chosen are based upon an expanded database of surveillance capsule results. Currently, the models that you see in 50.61 alpha are based upon about one thousand data points of Delta T-30 Sharpie shift values as opposed, for example, to the models that you see in 50.61 or in Reg Guide 1.99 (Rev 2) which, if memory serves were based upon roughly 200 shift data points. So we have about five times the amount of data today in terms of the development of these new models.

In addition, the models that we have developed combine both a statistical analysis of the available data with a mechanistic understanding of radiation embrittlement. So, the models are a synthesis of those ideas to, we think, provide the best characterization of what we know today in terms of the phenomena of radiation embrittlement.

And then as a result, they do incorporate a wider range of material characteristics, in particular phosphorus content, manganese content, as well as specific environmental variables like the neutron flux and the irradiation temperature or the cold leg temperature for the model characterization. Now, some of those variables, like irradiation temperature are sort of implied in the current Reg Guide and in the current PTS rule but these models more directly incorporate them into the models themselves.

And along with the new models, we have introduced updated reactor pressure vessels through surveillance data evaluation methodologies. These are intended to be used to verify the applicability of the embrittlement models in 10 C.F.R. 50.61 alpha. The notion in 50.61 alpha is that barring a demonstration to the contrary, the models in the rule should be used to predict the level of radiation embrittlement. This is a slightly different take than in the current regulatory structure where there seems to be a slight preference for putting plant-specific data ahead of the models in 50.61 or in the Reg Guide. We want to make a clear distinction here that we do certainly believe strongly in the general models that have been developed. We only want to have licensees performing separate plant-specific data evaluations or using that data in preference to the models when there is clear evidence that that should be done.

So the tests that have been developed, and there are three that you will have seen in 50.61 alpha were developed with the help of Lee Abramson from the staff to be more statistically rigorous and to hopefully to be able to identify any types of datasets that might exist which would indicate that the available plant-specific data is showing a meaningful deviation from the embrittlement model.

In particular, we are interested with

these surveillance data checks to find out whether there are any plants that have data that demonstrate that their data is deviating from the model at the high fluence levels. Because we recognize that this 1,000 surveillance data point data set is somewhat sparse at the very highest fluence levels. So we felt it was important in conjunction with putting these models together to also have as a check a look at plant-specific surveillance data to see if there was some statistically meaningful deviation from the plant-specific data, particularly as they continue to accumulate higher and higher fluence data. It is not that we don't believe in the models or how the models have been developed. It just warrants further monitoring and evaluation to see if there is data being obtained that suggests differently.

UNIDENTIFIED SPEAKER: When are we going to run out of surveillance coupons?

MR. MITCHELL: Hopefully, never. But certainly the number of available capsules, of course, is diminishing all the time as people take out capsules and test them. There is certainly a requirement to date in license renewal space for example, that licensees be able to obtain data which would allow, at a fluence level between one and two times their projected end-of-license fluence and that would include if end-of-license goes out to 60 years. So, there has been a move to require the acquisition of higher and higher fluence data.

We have also been in discussions with the industry about concerted efforts to make the best use of the remaining capsules to optimize the kind of data that we can get from those capsules to get data at more meaningful fluence levels that help push the database out to six, seven, eight, nine, E to the 19 and not simply repeat data over the same range that we have already acquired a multitude of data, two, three, four, five E to the 19 or least the lower end of that range.

So, there are a number of things that are going on. But that is certainly an active point of discussion between the staff and members of the owners groups and members of the industry who can influence the selection of when some of the remaining capsules will be taken out and tested.

UNIDENTIFIED SPEAKER: May I just restate what I think I heard over the last few minutes to make sure I have it?

In your model, you have gathered all of the data you have collected and that has, then uncertainty dealing with it. So, you are doing statistical tests on the Sharpie tests for individual plants to see if they are embrittling at a rate that does not fall within the bounds of the uncertainty of your model. Is that right?

MR. MITCHELL: That is effectively correct, yes. We want to make sure that they are well predicted by the model.

So, in closing this part of the presentation, I will just make a general statement that it is certainly the staff's position that the final rule provides an effective and useful approach for addressing the PTS issue by, first and foremost, maintaining an adequate level of protection as demonstrated by the state-of-the-art technical basis which supports the rule and the provisions that we have placed in the rule to ensure future monitoring of very relevant aspects of any plant-specific application of the rule without imposing unnecessary regulatory burden on the licensees.

Further questions?

DR. POWERS: Once when I was young and naive, I advanced the theory that we had perhaps done enough irradiation analyses and research program on heavy section steel. And I was told no, you are you naive; that there are things that will come about that will surprise us and, therefore, we should continue a heavy section steel irradiation program to the end of time because we could never know when we would be surprised.

Now I ask you. These surprises that were invoked to preserve the heavy section steel can arise here as well, I presume. Or maybe they only arise in research context and never in application. But on the off-chance that they do arise in applications, how does your state-of-the-art protect me there?

MR. MITCHELL: Well in particular, and you are correct Dr. Powers, there is some information, based upon test reactor irradiations, based upon computer simulation modeling of the effects of radiation on low alloy steel-type materials. That suggests that as you get to higher and higher fluences, new mechanisms may kick in which would change the rate of embrittlement. That is part and parcel to why we also retain the required surveillance data checks at this point in time in the rule, to ensure that if licensees began to acquire data that suggest from commercial power reactor irradiations, that such mechanisms are real and are in play in this context that we have advanced warning because those data will be acquired with lead factors that will put them in advance of the vessel in question.

So, the data will be available before the vessels reach that level of embrittlement.

DR. POWERS: I do like your answer. I think it was a good answer but I will have to ask.

MR. MITCHELL: Uh-huh.

DR. POWERS: Our current vessels, they have not been produced by anything that approaches a standardized process. And so one vessel can be unique, can it not?

MR. MITCHELL: Absolutely. Well, I would not say -- there are aspects, depending upon the differences in the fabrication process, which could at least make classes of vessels different. One thing that comes to mind particularly would be post-weld heat treating can change the distribution of free copper in some of the welds, which would make the welds, their sensitivity to radiation embrittlement different. If the copper gets tied up, it isn't free to form a fine precipitate field, then they are going to see less embrittlement with radiation.

As a class though, however, and given the fact that we continue to acquire data from the available fleet, I believe the data will be representative of the whole of the conditions that exist throughout the fleet, as a whole because we tend to have capsules --

DR. POWERS: I believe your answer is true as a fleet. But I am asking you about that one surprisingly unusual vessel for which it has not measured the capsule, therefore, has not entered its data point in your overall set still can surprise you. Can it not?

MR. MITCHELL: Well for each individual vessel they would be, by Appendix H requirements, would required to be essentially obtaining data in advance that applies to their particular vessel. So before that one unique vessel gets to, let's say, six or seven E to the 19 where these other mechanisms may kick in, they should have acquired a surveillance point at least at that level or beyond to be indicative of the behavior of that particular vessel.

So, I think we have it both covered on the specific, as well as the general field in question.

MR. KIRK: If you have got enough data to make it statistically significant, the question is whether that data point will get --

MR. MITCHELL: And that you mentioned is, I think, also why we have three separate tests in this particular rule. We didn't rely simply the first introduced test, which is sort of an overall deviation from the model from the entire dataset. We have an outlier test and we have a slope test, which we think also have additional sensitivity to finding data sets where the last data points, for example, may be the ones that start to show deviation from the model, whereas early data points were perhaps more accurately predicted. We didn't want to rely on a single --

(End of Tape 1, side 1)

(Begin Tape 1, side 2)

MR. MITCHELL: -- certain, you can envision certain sets of data that could vary in different ways that we would be interested in. So, we have introduced the three-set test that all have to be passed in order to have confidence in the application of the model.

UNIDENTIFIED SPEAKER: You are getting this early indication of embrittlement by the location of your capsule. So, you are collecting radiation damage at a higher rate, I presume.

MR. MITCHELL: Yes.

UNIDENTIFIED SPEAKER: And there has been the question, at least some people of raised that there is a flux dependence on radiation damage and that in fact you can make it usually worse collecting the radiation damage at a higher rate than but could it go the other way? In other words, you are trying to get lead information on lead radiation damage. Is there any downside that somehow in trying to get accelerated radiation damage you in fact are missing the real --

MR. MITCHELL: Yes. Having done graduate work in the area of radiation damage mechanics, there is never really an easy answer.

UNIDENTIFIED SPEAKER: I intend to believe in acceleration and it ought to make it worse but I don't guarantee that it could.

MR. MITCHELL: Depending upon the system in question, that may or may not be true. I think what has generally been held that the amount of acceleration we are talking about here is generally on the an order of a factor of three, three to five. It has been generally held that that limited amount of acceleration does not make a major impact on how the microstructure evolves. Now, if you are asking me the difference between commercial power reactor data and test reactor data, where you are talking orders of magnitude potentially difference. That could have a significant difference in terms of how the microstructure develops. But you will note that even in the ASTM standards prescribe, ASTM E185 for how a surveillance program should be developed, there is a specification on how much your lead factor can be. And the intent is to ensure that that data is a reliable indicator of what is actually going on with the vessel.

Now, I will note also that many vessels also happen to have capsules which have lead factors close to one, in some cases, in addition to having accelerated capsules.

UNIDENTIFIED SPEAKER: Oh, that helps a lot.

MR. MITCHELL: So that data, if it were necessary to be evaluated would also be potentially available.

If there are no more questions on the overview of the rule, I will turn it back to Veronica.

MS. RODRIGUEZ: Yes, thanks, Matt. We received very valuable comments from the stakeholders. We evaluated every single one of them and we provided a response. The (inaudible) received a separate package with the comments and the NRC responses.

With regards to the Proposed Rule, it was issued on October 3, 2007. The public was provided with a 75-day period for their comments. That period closed on December 17, 2007. We received five comment letters from the PWR Owners Group from EPRI, NEI, Duke Energy, and the Strategic Teaming and Resource Sharing or the STARS Group, for a total of 54 comments on the Proposed Rule.

With regards to the Supplemental Proposed Rule, this one was issued on August 11, 2008. Again, we had a 75-day period of comment. The period closed on September 10, 2008 and we received in this instance three comment letters from the PWR Owners Group, EPRI and FENOC. In this case, we received five comments in total.

The NRC approach with regards to the comments, we read and evaluated every single one of the comments, we assign an identifier number and we bin them into categories.

In the Proposed Rule we have four major categories or bins. The first one is embrittlement trend curves and fluence maps; surveillance data; flaw limits and flaw density determinations; and the last one is a miscellaneous category. On the Supplemental Proposed Rule, we have two major categories or bins. The first one, adjustment of ISI volumetric examination; and the last one, surveillance data.

UNIDENTIFIED SPEAKER: Is there anything in your treatment of these public comments that is out of the ordinary?

MS. RODRIGUEZ: Not really. This is typically --

UNIDENTIFIED SPEAKER: It kind of follows what everybody else does?

MS. RODRIGUEZ: Yes.

UNIDENTIFIED SPEAKER: Okay.

MS. RODRIGUEZ: This is the very typical process that we follow in the rulemaking. This is how we handle the comments. We try to bin them into categories. We try, to the extent possible, not to paraphrase or rephrase the comments so that we keep them in context and we don't misinterpret what the comments are saying.

So in this case, we try to minimize the amount of bins so that we can keep them focused on the areas that we needed.

So now Matt is going to try to give you a quick overview of the categories. It is very hard for us to go to the specifics, since we had a lot of comments. So, Matt is going to do his best to discuss those areas. And if you have more questions, just please feel free to jump in.

MR. MITCHELL: Yes, absolutely. It is, again, hard to do justice the volume and variety of comments that we received. But under the category from the original proposed rule or the embrittlement trend curves, I would say that the principal comment that we received was a request to consider removing the embrittlement model from the rule and, in turn, only require the use of an NRC-approved methodology.

The staff's response was that we disagreed with this particular comment. We felt that it was important to implement the models that we have chosen to put into the rule one, for consistency with what was used in the technical basis work, as well as to provide a sense of regulatory certainty for all of our stakeholders in terms of how this rule would be implemented. We felt that that point of clarity, to clearly lay out the expectation was valuable from everyone's perspective in terms of understanding how this rule would go forward.

UNIDENTIFIED SPEAKER: Well you certainly, since you get to write the Reg Guide, you could certainly ensure consistency with the technical basis.

MR. MITCHELL: Are you talking about in

terms of when we go to revise Regulatory Guide 1.99?

UNIDENTIFIED SPEAKER: Or you know, a different one if it comes to that. But I mean, you are in control of the NRC-approved methodology. You know, I thought you were going to tell me the lawyers made me do it. You know, then I would give up.

MR. MITCHELL: Well, I think --

UNIDENTIFIED SPEAKER: But since you didn't choose that route, --

MR. MITCHELL: I think there was consensus both from the technical, regulatory, and legal perspective, that this was a valuable way to write the rule, in terms of trying to provide the kind of clarity I was mentioning previously. So I certainly believe that Office of General Counsel agreed that this was a valuable approach.

UNIDENTIFIED SPEAKER: Yes.

MR. MIZUNO: The model then is frozen. It can't be changed without another rulemaking.

MR. MITCHELL: In theory, of course a particular licensee could choose to come in and request an exemption to use a different model. That option is always available to them under 50.12. However, they would have to demonstrate in accordance with the requirements for specific exemptions why we should approve their use of a different model. So, in effect, it is fixed by the rule.

MR. MIZUNO: I mean, there are benefits to taking this approach. One is that it is consistent generally with the approach that exists in the current rule. And the current rule adopted that approach, I guess, for consistency and predictability. Because that way, the external stakeholder, the applicant knows exactly what they are shooting for. And the internal NRC reviewer knows exactly what he is supposed to be looking at and presumably, there are internal checks to ensure that he or she asks for things which are outside of the scope of the rule. If he or she has concerns about that he either has to demonstrate that it comes up to the point where we are concerned about adequate protection or something like that. Otherwise, they are to confine their review to the criteria of the rule and, if necessary, open up a generic issue or go through the process of seeking a development of a new generic issue to be reviewed. I mean, that is our existing process.

So, I think that the approach that the staff chose to use in consultation with OGC is one that is well understood and has a lot of valuable benefits. And as Matt pointed out, if a licensee believes that they have the capability to develop and demonstrate the use of a different model or have new data sets to sort of extend existing models, they can always request an exemption.

And also, I guess, if any external stakeholder feels that the rule needs to be further developed and can be done in a rulemaking context, they can submit a petition for rulemaking.

UNIDENTIFIED SPEAKER: But again, the thing I dislike about this, we end up now with maybe three break sizes for leak before break. You know, we are going to have a couple of embrittlement models. You know, sometimes you use 1.99, Rev 2, Rev 3. Sometimes you use the stuff that is in the rule.

MR. MIZUNO: Right. That was OGC -- one of the points that OGC brought up back when the original rulemaking plan for this went forward and these were raised both with the staff and ultimately to the commission. And quite frankly, the commission directed us down this approach and, you know, they made that policy. The understood what was going on here. I would agree with your observation that, in part because of the limits of the Backfit Rule, I mean, everyone in this house knows what the limitations are there, that it is very difficult to come up with a rule that mandates a new approach where an agency is unable to find a problem with the existing approach.

MR. KIRK: This is a voluntary rule.

MR. MIZUNO: Yes, that is what I mean. So to the extent that it is voluntary, you created the potential for another way of looking at things. So therefore just by doing that, if you want to call it inconsistency, that is what it is.

MR. MITCHELL: It is going back and changing the existing rule, if we wanted to invoke consistency where then the Backfit questions of course come up. And as Geary pointed out, we were instructed to not worry about having to have that level of consistency between what we have in 61 versus what we have in 61 alpha.

MR. MIZUNO: And I guess as I think I will also point is that this area of embrittlement exists not just with one regulation but we have several different regulations that all address phenomenon and concerns in this area and each of them have to be treated from a Backfitting standpoint separately.

UNIDENTIFIED SPEAKER: It does lead to ossification.

MR. MIZUNO: I would agree. But on the other hand, there are certainly stakeholders who feel that that is an appropriate regulatory approach, I guess.

MR. MITCHELL: With regard to the evaluation of surveillance data, in response to the original Proposed Rule from 2007, we did receive comments which I would say principally suggested that we could perhaps eliminate the requirement to continue the evaluation of surveillance data, in large part because variability in surveillance data results was already included in the derivation of the model.

I would just reiterate that for reasons I think we talked about extensively just a few moments ago, the staff declined to agree with that comment as well, finding continued value in the evaluation of plant-specific data as a protection against non-conservatism from the model, particularly at high fluence levels.

On the category of the flaw limits and density determinations, I didn't choose to pull out any particular single comment. I think I could have pulled out the same comment which said could you please get rid of this also from the rule but there was also a vast number of other comments which actually helped us to refine the way that we represented this and the requirements that we placed into the rule.

So, there were certainly aspects of the public comments that we received that we endorsed, that we used to help clarify what is being required in the rule. There were other comments that we declined to agree with because we didn't think that they either helped the clarity or the utility of this particular section of the rule.

UNIDENTIFIED SPEAKER: But none of them changed the basic structure of the rule.

MR. MITCHELL: None of them changed the basic structure. I guess I would say one of the main changes that we made, there is a requirement in the rule, it is now in (e)(6), it talks about submitting a neutron fluence map. That neutron fluence map which helps to describe the level of embrittlement in the vicinity of particular indications. That got moved to (e)(6) and is now only required if a licensee ends up with a flaw distribution that requires additional analysis.

So if my memory is correct, in the original proposed rule, that was sort of a baseline expectation. We have now moved it the category that says only if you have a distribution contrary. So that might have been one of the more major evolutions that we made based upon that particular set of comments.

In the category of miscellaneous comments, again, as you can guess, there was probably no single principle representative comment, but perhaps one of the more interesting ones was one that we received from Duke Energy regarding specifically the evaluation of steam generator overfeed events. I have tried to keep this discussion kind of short and simply to say that in response to that particular identification, we did go back and we re-evaluated that particular event sequence. We had some additional favor runs performed to ensure ourselves that the sequence in question that the commenters from Duke identified in fact did not make a significant impact on the determination of the screening criteria in the rule.

Again, if memory serves correct from the documentation, I believe we concluded that that particular event contributed about ten to the minus eight value in through-wall cracking frequency. So given that the criteria were already being set at a value of ten to the minus six, if you go back and add ten to the minus eight to ten to the minus six, you are not going to get a significant effect on where we were establishing the screening criteria.

Again, I have given this a very brief treatment in this regard and if there additional questions, we can certainly go into it further. But that was sort of the bottom line in terms of, but we did perform significant additional analysis to convince ourselves that that was not something that we had missed in the original screening criteria development.

Then in response to the supplemental proposed rule, we got comments back that where the commenters did agree with the NRC staff's proposal to incorporate this potential consideration of NDE uncertainty into the rule and to allow licensees that flexibility to perform that demonstration. And of course, sine it was kind of our idea, we agreed with that particular comment and modified the final rule to incorporate that language. So, that was a relatively easy one to resolve.

UNIDENTIFIED SPEAKER: You should have been consistent and rejected it.

MR. MITCHELL: Well we had to demonstrate that we agreed with something.

Finally, we got additional comments on our enhanced surveillance data evaluation procedures. In particular, a principle comment was that we might eliminate what we have called slope check, which again is intended in particular to provide information out at the higher fluence levels to see if the trends in the licensees begin to swing away from the embrittlement model. Again, we declined to agree with that particular comment because we found value in that particular test and its ability to discriminate particularly those data points that we will be getting at the higher fluence levels.

So certainly, I would echo what --

UNIDENTIFIED SPEAKER: -- opportunities to data that did not have the slope check?

MR. MITCHELL: I'm sorry. Could you repeat the question?

UNIDENTIFIED SPEAKER: You forecasted opportunities to exclude data if you did not have the slope check?

MR. MITCHELL: We believe that there could be datasets which were giving us meaningful information that should be paid attention to that might not be identified if the slope check was not incorporated within the Rule, that might be missed, that could stand further evaluation. There were scenarios.

MR. KIRK: Yes, it sees to me, I mean, you want your statistical test to be inclusive here and to be slightly weighted to the conservative side. I mean, if there is a potential for higher embrittlement, you want to give it the benefit of the doubt. I mean, that is one trouble with the surveillance data that we have such limited amounts of it.

MR. MITCHELL: Correct. And we think that the way we structured these particular tests does have some more statistical rigor in its consideration of just how many data points you are going to have and what a statistically meaningful deviation is going to be for any of these particular checks. We did put considerable effort into making sure that we did have that type of verification for what we were --

UNIDENTIFIED SPEAKER: You know already that if somebody pulls a capsule, whatever the standard number of samples are that they can test, that there will be enough data points that they would be statistically significant and not create a problem when really it is just a problem with not enough data point.

MR. MITCHELL: Well, just to clarify, when we talked about --

UNIDENTIFIED SPEAKER: I have never done any of this so I don't know how many samples come out, how many tests you get.

MR. MITCHELL: Well, when we --

UNIDENTIFIED SPEAKER: It is never enough.

MR. MITCHELL: It is never enough.

UNIDENTIFIED SPEAKER: Yes, I know, but is it ten or is it a hundred?

MR. MITCHELL: And just to be clear, when we are talking about data points, we are talking about a single capsule and a specific surveillance material from a capsule will give you a data point. It will give you a value of shift. Now, to get that shift, you may test eight or ten Sharpie specimens to define the curve but you will get a single shift data point from that capsule for each surveillance material. Or if it is a plate and you have both orientations, longitudinal and transverse, you might get two values. But in large part, it is just one value per material.

And then put those data points together

when you do this evaluation. In most cases plants will have a minimum of three and more likely four, five, or six as they progress to higher levels of embrittlement. You know, that amount of data is the amount of data that we are going to have for each individual facility. And the tests are designed to account for the fact that we expect to have that many data points. And the acceptance criteria are set up to be weighted or to be scaled, based upon the number of data points that we have to make them statistically significant. Or to identified if the deviation is statistically significant.

UNIDENTIFIED SPEAKER: But it protects you against an overly (inaudible) alarmed, I would think somehow because --

MR. MITCHELL: Yes.

UNIDENTIFIED SPEAKER: -- you still don't have enough data. Maybe you wait until the next capsule.

MR. MITCHELL: Yes, I think --

UNIDENTIFIED SPEAKER: Or you would do something dramatic or conclude that you are on a wrong trend or a bad trend.

MR. MITCHELL: Yes. Ii think if I am interpreting your comment correctly, I think the answer to that is, indeed, yes.

UNIDENTIFIED SPEAKER: Yes, I just wanted to understand that.

MR. MITCHELL: And I will just note in addition another theme of the comments, another thing that was certainly considered was the question of should the rule prescribe how you should evaluate or what you should do for a plant-specific evaluation to get modified RT_{MAX} values based upon having datasets that deviate from the model.

And of course, given that we could not a priori assume what that deviating dataset would look like, the Rule only requires that the licensee develop a proposal as to how they are going to account for that plant-specific data and adjust their RT_{MAX} values to account for it. So we did not try to write that into the rule.

UNIDENTIFIED SPEAKER: Giving up regulatory certainty, no doubt.

MR. MITCHELL: When we could not provide it, in this particular case, yes.

So, we are hopeful that that will be the vast minority of the cases where we even have to deal with that particular outcome and that the model will hold in the vast majority of the cases, because the plants will pass the criteria. But we didn't --

UNIDENTIFIED SPEAKER: What plants do you actually anticipate picking their (inaudible)?

MR. MITCHELL: The current best estimate is that there are probably between eight to twelve of the operating PWRs that could have difficulties meeting 50.61 through the end of an extended license period. That number varies, again, depending upon what they know about their current best fluence data, surveillance data, etcetera, but eight to twelve is the ballpark.

UNIDENTIFIED SPEAKER: If one went to like beyond 60, how many plants?

MR. MITCHELL: The answer is certainly more. I think Mark has developed some slides that suggest --

UNIDENTIFIED SPEAKER: Does your number also include the fact that the people might decide to operate power and stop limiting fluence? I mean, all of the little sacrifices they have made in order to make sure they don't violate, you know, they might go peddle to the metal here.

MR. MITCHELL: No. Eight to twelve is based upon best current available knowledge. It doesn't take into account -- but you are absolutely right, they may make modifications that would take advantage of having additional flexibility.

And I guess the other thing of course that we have been sensitive to as well is that some of the modifications that plants have made over the years to remain in compliance with 50.61 are not a free lunch either. Reducing power in a particular region of the core due to flux suppression, just pushes that power elsewhere. And if you want to operate it of course at the same thermal power level and same electrical output. So, do you push your peaking factors higher in other parts of the core in order to do that. So it is --

UNIDENTIFIED SPEAKER: Money, too. Neutrons are dollars.

MR. MITCHELL: Yes, we try to stay out of that particular end of the world a little bit more. But even from a safety perspective, some of the things that have been done can have at least modest or minor negative safety impact by how you are modifying the cores or other steps the plants are taking to meet 50.61. So, if there is --

MR. KIRK: The numbers are not insignificant. I mean, even eight to twelve. And if it creeps up a little bit it still --

MR. MITCHELL: Yes, for a lot of reasons, that number could increase; EPUs, removing flux suppression, going to 80 years. Yes, there are a lot of ways that number goes up.

CHAIRMAN SHACK: Well, I think this is a good point for a break. And we are just about on schedule. Amazing.

MR. MITCHELL: Close.

MS. RODRIGUEZ: First time.

CHAIRMAN SHACK: Ten minutes. Ten minutes in an ACRS meeting, that is right on target.

Let's come back at 3:15.

(Whereupon, the foregoing meeting briefly went off the record.)

(End Tape 1, Side 2.)

(Begin Tape 2, Side 1.)

MR. KIRK: -- three different graphs. The horizontal axis on each graph is the maximum reference temperature. So that is a metric of embrittlement. It is plotted versus ranking so I don't wind up, well, A to annoy people, and B, so I don't wind up passing an exponential curve through zero, ranking is subtract 460 and you get Fahrenheit. But anyway, what is on the --

UNIDENTIFIED SPEAKER: You still haven't

gotten anything yet. What is wrong with civilized units, especially in NRC's Research?

MR. KIRK: I like ranking because he is a Scottish civil engineer and that just appealed to my heritage, so I stuck with it. That I thought was a compelling reason.

UNIDENTIFIED SPEAKER: It's the only reason I can think of.

MR. KIRK: Scott versus Lord Calvin?

UNIDENTIFIED SPEAKER: There was just no choice.

MR. KIRK: So, on the three plots, the plots show you the three classes of transients that collectively represent I think it is the 99.99 percent of the total through-wall cracking frequency. On the left-hand side is medium to large diameter pipe breaks and I realize that is a little fuzzy. By medium, in this case, we mean pretty much five inches and above. These are transients, of course, that feature a very rapid depressurization and consequently very rapid cooling of the primary. There is some pressure but not a very significant contribution in pressure. Kind of takes the P out of PTS.

But the thing to point out is the common factor here is that in all cases, the rate of temperature drop in the primary inventory is so fast, that the vessel cannot keep up. This is a condition that we have developed, I guess, our own slang for, we call it vessel limited, which is to say it is actually a good thing for generalization that a lot of the details don't matter. Once you are cooling at a rate that is consistent with say a five inch or larger pipe break, the steel can't keep up because of its finite thermal conductivity.

So whether you have got a five inch break or a 16 inch break or whether it is in the summer or the winter, all these nuances really just fade to black and what is important is that you have had the break.

MR. BLEY: Mark, can I ask you a couple of questions?

MR. KIRK: Yes.

MR. BLEY: This is the only slide you have with kind of quantitative results on the three PRA?

MR. KIRK: Yes.

MR. BLEY: These are some amalgam of the results from the three PRAs.

MR. KIRK: Yes. Yes, this represents -- I mean, what is on here represents --

MR. BLEY: As I go from one to the other, things are a little different what is contributing the most to the through-wall cracking frequency.

MR. KIRK: Well, the overall story is, I think, similar between the three plants that we will get to. Because on the next slide, which I don't want to go to right now, it compares the trends that we have drawn through all three plants. But in general, what you will find out is that primary breaks, be they medium to large diameter breaks or stuck-open valves that later re-close, contribute basically 90 percent of the through-wall cracking frequency and the secondary breaks contribute the remainder.

MR. BLEY: I noticed in Beaver Valley, for example, it looked like the biggest single, well, one of the biggest ones there was a small LOCA and not a medium or large. But if looking at the bin frequencies and I might be reading the tables wrong, the large and mediums that I am seeing here, contributions mostly from mediums, the largest contribution was lower but that was because they are initiating event frequency.

MR. KIRK: That's right, yes.

MR. BLEY: But if I am reading the tables right, the chance of the through-wall crack, given the large LOCA, looks like it is nearly one. I mean, in the detailed initiating up front frequencies and bin frequencies in the actual PTS report, am I missing?

MR. KIRK: I'm sorry. Say what you said again. The chance?

MR. BLEY: The conditional probability of failure is close to one, given a large break LOCA.

MR. KIRK: At a high enough embrittlement.

MR. BLEY: Yes. I mean, I --

MR. BLEY: For these three specific plants where the PRA was done.

MR. KIRK: Yes, I would have to check but the, yes, and that was, I think a major difference that we had to try to understand, relative to the old results where large LOCAs weren't blamed for anything. And the reason why large LOCAs weren't blamed for anything in the old results is it was assumed that you needed a P in PTS. And that turned out at a high enough embrittlement to not really be true.

MR. BLEY: Yes, I guess where I was going with this and this is a little, since we don't have those results out here, maybe we will -- if in fact the chance of a large LOCA, -- the chance of the through-wall crack, given the large LOCA is in fact nearly one, --

MR. KIRK: I don't think that is the case but go ahead.

MR. BLEY: -- this is only for extreme embrittlement. I am wondering what that does to our basic design basis.

MR. DINSMORE: Yes, this is Steve Dinsmore. I guess since the guideline they were using was ten to the minus six, even at the highest embrittlements, --

MR. BLEY: It is still a ten to the minus six.

MR. DINSMORE: Well, the large LOCA frequency is three times ten to the minus five. So it is going to be at least not quite one.

MR. BLEY: It is not. You are right, it is not. It is close.

MR. DINSMORE: It might be close.

MR. MITCHELL: I was just going to interject and ask and maybe I am misunderstanding the reference that you are looking at but I think if you are looking at the very highest levels of embrittlement that these plants were run to in the technical basis work, those were levels of embrittlement which far exceed anything that is actually expected from a practical application standpoint. Mark, can you help me out here?

MR. BLEY: These are coming out of the PRA. I don't know what embrittlements they took the PRA to. Did it go up to 100?

MR. MITCHELL: For some of the --

MR. DINSMORE: There is this extra complication here from the PRA site. It changes with time and they didn't take it out to just 60 years which I thought they were going to do. They had to take it way out beyond into some Never Never Land.

MR. MITCHELL: A hundred, five hundred.

MR. KIRK: Yes, so the ones, I believe the results that you are referring to where you say if the large LOCA happens, the conditional failure probability is verging to one or one to ten or something where we would all think we should be running quickly in the opposite direction is like Matt said, those should be associated with the very long embrittlement times that we just don't expect and see.

MR. DINSMORE: At 60 FPY, which is kind of where you would expect, that is kind of what we were looking at.

MR. BLEY: That is what I thought these were done at.

MR. DINSMORE: No, the conditional probability of failure at 60 FPY for a large LOCA is seven times ten to the minus five.

MR. BLEY: Really?

MR. DINSMORE: Yes.

UNIDENTIFIED SPEAKER: For the worst of the three?

MR. DINSMORE: Yes.

MR. BLEY: Okay. Thanks, that helps a lot. There was something in there that I wasn't clear on. Good enough.

MR. KIRK: Okay, so that was the medium to large LOCAs. Another, the other major contributor, I should say, are stuck-open valves on the primary side that may later re-close. Due to the valve size, just the valve opening is more like a small break LOCA. It is like a two or three inch diameter opening, which in and of itself would not be particularly challenging at all, given the material conditions we are looking at but it is the late-stage repressurization when you add the pressure stress to the thermal stress and the low temperatures that get you.

So that is another major contributor and then we have got a minor contribution from main steam line breaks. Of course, the main steam line break features a screening fast transient at the beginning and full system pressure but the distinguishing feature that keeps that from being a bad actor is that the temperature in the primary can never go very low, relative to what it can for a large pipe break.

So if we go to the next slide, this one is a little easier to read. It is the curve fits through the data that we generated for the other three plants, where we are expressing the contribution for each of these transient classes to the total through-wall cracking frequency. And what you see is that at low embrittlement levels, now we are into degrees Fahrenheit, at a reference temperature of about 200 degrees Fahrenheit or even say 210 degrees Fahrenheit, which would be consistent with what our current screen limits are, we have got roughly an equal contribution of medium to large diameter pipe breaks and stuck-open valves that may later re-close.

However, as we go up to reference temperatures like what the proposed alternative screening limits are of about 270 to 300 degrees Fahrenheit, the situation changes and the medium to large diameter LOCAs begin to dominate. The stuck-open valves are going down and main steam line break is making up all of the rest.

If you remember the previous slide, of course, this isn't to say that as embrittlement goes up the conditional failure probabilities due to any of these transient classes are going down, they are all going up. That is what was showed on the previous slide. They are just going up at slightly different rates.

MR. DINSMORE: And Dennis, again, this is Steve Dinsmore. This is time going off to the right. They call it temperature but I think it is easier --

MR. BLEY: It's time. Yes, sure, I understand.

MR. DINSMORE: -- for the PR people to think of it as time.

MR. KIRK: Yes, the reason, of course, why the materials people confuse things and put temperature on it is not only to suck in thermal hydraulicists to think that they might understand what we are talking about.

But it is just to recognize that 60 years in a non-embrittlement prone vessel is something that might have low copper and low nickel is not the same as 60 years for something with 0.3 copper and 1.5 nickel. So, but you are right. It is a quasi-time axis as well.

So, if we go to the next slide, I think I have probably said all of this as I have been working through. We find out that very severe secondary faults, i.e., main steam line break, make only a minor contribution. Again, the explanation for that is that when you have a break in the secondary, the primary just can't get that cold so the material doesn't get that brittle. The primary side faults therefore dominate the risk because the primary side temperature can fall considerably below the boiling point of water.

And then all of the other transient classes produce no significant risk. Things like feed and bleed, the transient that Duke was worried about that they mentioned in their public comment, when you run all of those, you find out that the challenge is low, even if you assume that the transient occurs.

So to go into these each in a little more detail to try to set the scene for do we think generalization is possible, we wanted to try to look at our findings on these, I will call them two dominant and one minor transient classes to try to understand what are the features that are making them dominant, what are the major contributors to failure and to see if we would believe that those features would be generally similar across the fleet or generally dissimilar.

So starting with the, here we are on the slide for stuck-open primary valves. As we saw on the graphs, these dominate the risk at low embrittlement, but their significance drops off as embrittlement increases. The reasons for the failures here are driven by factors that are generally similar across the PWR fleet. Once you open a valve and let it cook for three to six thousand seconds, the temperature in the primary is approaching the temperature of the injection water, which is reasonably similar across the fleet.

Also, the thing that gets you again, if it was just that fairly gradual cool down to a fairly low temperature, that in and of itself wouldn't be enough to cause a problem. You need that late stage re-pressurization. And when the re-pressurization occurs, it is very digital. Either the operators act very rapidly and stop the re-pressurization from happening or they don't act very rapidly and the plant will re-pressurize to the safety valve setpoint. The safety valve setpoint is every similar across the fleet.

We note there, and I just said this, the rapid operator action, meaning in this case throttling of HPI in less than a minute after the throttling criteria are met, can indeed influence the scenario; however, even if we remove that credit for operator action, the screening criteria will not change.

So this is one of those where Steve and I have had considerable differences of opinion and heated arguments about the meaning of the word influence. When I say that something has no influence, I mean, it doesn't have any influence on our bottom line reference temperature screening limits. Where Steve and I have had differences that we finally understood is that when he says influence, he means well did the operator actions have an effect. And certainly the operator actions have an effect over the course of this transient, if the operators act rapidly. But when you integrate all the results together, you find out that it is just not that big a contribution.

And the other factor to bring in here is like I said earlier. We did analyses of these transients and all transients for two basic starting conditions, full power and hot zero power. And what we found out, of course, is when a transient initiates from hot zero power, sine there is less heat in the system, you get generally a more aggressive transient. You have much more rapid cooling and it goes to lower temperature.

And it turned out in our analysis of these transients, it was only when these transients, the stuck-open valve transients where the operator was ineffective at throttling, only when they initiated from hot zero power conditions were they severe enough to count. And since hot zero power conditions represent a relatively small percentage of the total operating time, that is another one of the reasons why, when we look at this as part of the integrative whole, the credits for operator action, while they are very important, if you are focusing on that particular transient alone in terms of the overall integrative result and, thus, the overall reference temperature limit, don't really make much of a difference here. And actually that is good news for generalization because if operator actions were significant to the bottom line result, then I think we would have a more complicated rule because we would have to check that.

MR. BLEY: They are not significant to the bottom line results because the scenarios in which they are involved, operators weren't there, are low enough frequency that they are not a big impact?

MR. DINSMORE: A low enough through-wall crack frequency.

MR. BLEY: That's what I meant.

MR. DINSMORE: Yes.

MR. KIRK: Yes. Going to the next slide, where we go into a little bit more detail on the generality of our results on medium and large LOCAs, as we said, that is an important but smaller contributor at low embrittlement but as we go up to higher embrittlement, we find that apparently we don't need the P in PTS.

MR. BENSON: And even that is deceptive because when you say it is not as dominant at low embrittlement, the total frequency at low embrittlement is so low --

MR. KIRK: Well, that is right. A couple of ten to the 13ths and we are still not to work, even though we are conservative regulators.

MR. BLEY: Did you write down somewhere, because I know you found them, you know, if one can show from these three PRAs that the conditional probability of through-wall crack, if you could show the conditional probability of the through-wall crack for each of the three or four key initiating events and multiply that by the initiating event frequency, assuming no operator actions, that would be a really convincing story, it seems to me. The numbers are turning out the way it sounds as if you are telling me they are.

MR. DINSMORE: We could do that. We haven't done that. I think what happens is we keep saying that the medium of the LOCAs, nothing really matters until you get to the point where you are hitting the acceptance. Correct me if I am wrong.

MR. KIRK: All right. Go ahead.

MR. DINSMORE: When you hit that through-wall crack frequency of ten to the minus six, then you back out there some of this reference temperature. So unless you have actually got a sequence that are going to ten to the minus six, those sequences aren't going to make much difference.

MR. BLEY: Right.

MR. DINSMORE: So but you don't get to ten to the minus six even for the LOCAs until you get out to several hundred years.

So these sequences, the embrittlement goes up. The conditional probability of failure given the sequence goes up over the years as well. But for the sequences with the operators in them, they of course retain their initial frequency because that stays the same. But even if you multiply that initial frequency by the slightly higher conditional probability of failure at the end of 300 years, you are still less than the much higher failure given a LOCA, which you would multiply with the LOCA frequency, which is what will drive the result.

MR. BLEY: I think getting -- my point is, right now we have to see, and other people do, you have to see these results, further results of the PRAs and the studies, where all of this stuff is kind of compounded. If the situation is as clean as it sounds as if you are saying, some simple summary would go a long way to making it very convincing.

MR. KIRK: I think you are right and we have convinced, at least I have convinced myself through a thought experiment, that you don't need to run the calculations but of course people like numbers.

If we can back up to slide 30, I think I can maybe make the point here.

MR. DINSMORE: We need to stick with one time. That is what is confusing.

MR. KIRK: Yes, okay, breaking to the bottom line, which is in a backup chart, for an axial weld reference temperature of 270, 269, that is inherently our screening limit. And if you look at slide 30 and you draw a vertical line at 270, you find out that at 270, pretty much three-quarters of the through-wall cracking frequency is attributable to medium to large break LOCAs.

And once you have got a medium to large break LOCA, there is nothing the operator can do. There is absolutely --

UNIDENTIFIED SPEAKER: Who cares?

MR. KIRK: Yes, they have got to keep the core covered. The automatic safety systems are doing what the automatic safety systems do. And whatever they do, has happened before or after, I should say, the vessel might have failed anyway.

So, you have got three-quarters of your total through-wall cracking frequency that there is no operator action credit to turn off. So, you have got, what, 7.5 times ten to the minus seven. And so now you have only got 2.5 times ten to the minus seven that is attributable to everything else, most of which at that reference temperature is the stuck-open valves that later re-close. The only way stuck-open valves that later re-close even counted was when you were initiating from hot zero power, which is what, five percent of the time. So you have gone on out of 20 of 2.5 times ten to the minus seven that might have had an operator action credit. I think it is, I mean, I agree that numbers are good but I think if we reran the numbers, I would have to make my plotting symbols smaller for you to see the difference in the integrative results.

MR. BLEY: The other 20 percent, that is not -- coming from the smaller LOCAs.

MR. DINSMORE: So you are asking what would happen if we took the operator failure to zero and not 20 percent?

MR. BLEY: Uh-huh.

MR. KIRK: But that is what I am saying. Of the 20 percent, the 20 percent is made up of the hot zero power.

MR. DINSMORE: Right.

MR. BLEY: It's only five percent.

MR. DINSMORE: Right.

UNIDENTIFIED SPEAKER: Did you find any condition where you would have the optimum of pressure and cooling rate? It just didn't exist. So pressure became unimportant?

MR. KIRK: Well, I'm sorry. You mean the perfect storm?

UNIDENTIFIED SPEAKER: Yes, exactly.

MR. KIRK: No because I mean, the perfect storm would be a screaming fast transient and holding at full pressure. And you can't get --

UNIDENTIFIED SPEAKER: You know, I am just saying where you have some depressurization but still a pretty fast transient. There was no such thing.

MR. KIRK: No. The only way you can hold significant pressure is in a secondary side break and then you have got the high thermal stresses but the temperatures don't go low enough to matter for the materials that we are looking at.

So no, there was, I think the short answer to your question is there really was no perfect storm.

UNIDENTIFIED SPEAKER: Do you label this as thermal shock?

MR. DINSMORE: Yes.

MR. KIRK: That has been suggested several times, yes.

Well, I mean, pressure, it should say that pressure does matter. That is the reason why the stuck-open valves of the late stage re-pressurization matter.

MR. DINSMORE: But it doesn't matter for the blue line on that chart you just had.

MR. KIRK: No the blue line is not effected. And the main steam line breaks, yes, there is pressure but well, A, they are a small contributor and B, it is not the pressure that is killing you. It is the full-system pressure plus the thermal stresses are giving you a very small failure probability.

MR. BLEY: I am not sure you are not double counting that five percent of the time for the hot zero power. I kind of like Steve's idea where I just sort of zero out the operator action and see what that would do to it. And that isn't quite so clear to me.

MR. DINSMORE: We can do that this evening.

MR. KIRK: Did you say this evening?

MR. DINSMORE: No, we can't do that.

UNIDENTIFIED SPEAKER: Mark, this percentage, since that is coming from the PRA, ought to include the fact that you are only at the zero power.

MR. KIRK: Yes.

MR. BLEY: I mean, this is not a conditional probability, Mark.

MR. KIRK: Yes, you are correct. You are correct. I misspoke, yes.

UNIDENTIFIED SPEAKER: If there were another TMI, save the vessel and melt the core.

MR. KIRK: Okay, so I think I backed up from slide 33. So, if we could go back there and I think I have made the points that I wanted to make here is that for medium to large LOCAs, operator actions are just not relevant. And then -- go ahead.

MR. DINSMORE: Well, as you indicated, we have had many discussions about that use of the word relevant there. And I think they are relevant and they are credited as we normally credit them in PRA analysis and they are included in the numbers, to some specific situations that Mark deals with that they don't make a difference on his final result.

MR. KIRK: Yes, and that is what I mean by they are not relevant.

MR. DINSMORE: Every time he says they are not relevant, that is -- but they would make, if you zeroed them out, except for this very final result, if you get down towards the lower end of the time --

UNIDENTIFIED SPEAKER: It doesn't make any difference.

MR. DINSMORE: -- were those scenarios are already dominant, even though they are ten to the minus nine or ten at the early years, when you get down there --

MR. BENSON: Yes, I think that is the thing to keep in mind. When they are dominant, we almost don't care. But as you approach the ten to the -- you know, there is a little transition there.

MR. DINSMORE: Yes.

MR. BENSON: There is certainly a weak influence, I would think but --

MR. DINSMORE: At the high end, yes.

MR. KIRK: Okay and then if we could go to the next slide, this just talks to --

MR. BANERJEE: I have to ask you --

MR. KIRK: Go ahead.

MR. BANERJEE: I am trying to understand that. It says that the rate of cooling that is capable by the -- I mean, suppose I change the boundary condition on the wall. What happens to the wall is not effected by the (inaudible) condition?

MR. KIRK: Not once you get beyond a cooling rate that is characteristic of about a five inch break.

MR. BANERJEE: Well, let's just take a problem. I have boundary at T-zero into T-one and then I look at the temperature we are at going through that boundary. Really it depends on the rate of change between --

MR. KIRK: No. No because the water can cool very, very fast, whereas the steel has a much more thermal inertia, much less ability to conduct the heat. So, what the -- the stainless steel helps, too.

I mean, okay, here is an example. If I have an inch thick plate of steel, okay, if I don't have an inch thick plate of steel and I have got a fire hose shooting out water that is just barely water, it is not ice, and I hold my hand up, my hand gets really cold really fast. But if I put an inch thick plate of steel in the way, it takes a considerable amount of time to get through.

UNIDENTIFIED SPEAKER: I think all Sanjoy is saying is quantitatively, you are saying all the heat transfer coefficients computed (inaudible) for a constant temperature value. But as you got a plate that is transient reduction, either I put a fixed temperature at this point or I put a fixed heat transfer coefficient with the temperature, if the fixes are big enough, they behave the same way, given the thermal connectivity.

MR. BANERJEE: It is a dominant resistance.

MR. CORRADINI: I look at it a slightly different way. I think what he is saying is okay, I make the surface of this thing one temperature, T, but I have to then, I only get thermal stress if I am constraining the strain of that material. Well if that is a very thin layer of material that is at that temperature, it is easy for me to constrain that deformation. And I don't make much thermal stress. So I have to cool down a fair chunk of the material. And it is cooling down that chunk, I can change the temperature at the surface up and down as rapidly as I want but to say cool the first quarter inch of the material, I am really limited by the conduction into the steel.

And so, I think that is --

MR. KIRK: Yes.

MR. BANERJEE: The way I would interpret it, Mike, is the only transfer resistance lies on the metal side.

MR. CORRADINI: Right.

MR. BANERJEE: So, rather than on the --

MR. CORRADINI: But they are saying something more than that. They are saying they need to cool it down before things get ugly.

MR. BLEY: Kind of the way I think that inside has got to shrink a little bit to create the stress and it has got to be thick enough to be able to exert that.

MR. BANERJEE: But why this is so strange is suppose you had (inaudible) which were fairly stable coming down. I had stable regions where these (inaudible) went and you would get regions where you got no heat transfers and regions of very high heat transfer (inaudible) sort of alternative. Right?

Now, I know that these RELAP calculations and stuff that have been done, obviously can't take this effect into account. So let's assume that it can't. And what you are really saying is it doesn't matter. Is that what I hear? That if I add alternate (inaudible) coming down the (inaudible). Does it matter that the (inaudible) and not a uniform heat transfer?

MR. CORRADINI: Well, no. That is a different argument but it still doesn't matter. If you want to get into that question.

MR. MITCHELL: No, but can I rephrase his question? What I think he is trying to generalize to is (missing audio) and you need a (missing audio). The temperature zone could be highly fluctuating. It didn't have to be teasier (phonetic), it could be teasier (phonetic) plus or minus 20 percent. It doesn't matter. That is kind of what --

MR. KIRK: Yes.

MR. BANERJEE: Dave, you have been involved in this. How did you justify these RELAP calculations being good enough. Can you tell us? I am always following this slight of hand, baffle the eye a little bit.

DAVE: Well the simple answer is read NUREG 1809.

MR. BANERJEE: I know. I read it but I am still baffled.

DAVE: The experimental data showed a down is well mixed.

MR. CORRADINI: It is APEX you count on not RELAP.

MR. BANERJEE: Really? That makes me --

DAVE: But it wasn't just APEX. I mean, we ran a specific experimental program in APEX.

MR. BANERJEE: I think I like his argument better than yours.

MR. CORRADINI: Well his argument says that even if that argument is wrong, it still doesn't make a difference.

MR. BANERJEE: Yes.

MR. KIRK: But there is another structural argument that we can get into is that the APEX experiments, as I understand it from Dave, demonstrate that while there may be significant thermal streaming, Delta Ts that change as you go around the vessel at the elevation of the nozzles, once we get down to the belt line where the embrittled material is, the magnitude of those differences between the far field and the streams is much smaller on the order of ten degrees C, if I remember.

But also the other thing to keep in mind is those that non-uniformity in the thermal grading as you go around, only increases the axial stresses. It doesn't increase the circumferential stress appreciably. And when we look at from a material and structural viewpoint, when we look at the flaws that can propagate through the vessel, it is only the axial flaws that really stand a chance of punching through.

So, since the potential thermal streams of whatever magnitude they might be, and you can argue about what that is, only influence the axial stress. They only increase the driving force on the circumferential cracks. And because of the cylindrical geometry, those circumferential cracks just can't make the way all the way through the vessel.

MR. BANERJEE: So just getting aback to, just for clarification, if you had temperature going up and down the vessel where you had poured water, let's just postulate, and a region which was not, had vertical regions, wouldn't you get some circumferential stresses due to the going from the cold to the hot?

MR. KIRK: Not nearly as much as the axials. Because you need the length of the plume for it to generate the stresses due to the constraint of the metal.

MR. BANERJEE: (Inaudible).

MR. KIRK: Yes, and I wish I remember what I said.

UNIDENTIFIED SPEAKER: But is coming back to you. It is a matter of the area of influence, as well as the depth of penetration that you have to get some critical size before the thing starts to --

MR. BANERJEE: I buy the depth of penetration argument.

UNIDENTIFIED SPEAKER: But it is also point of influence, too. That was his point when he was trying to explain it to us before.

MR. SHACK: The bigger the patch you need to constrain, the bigger the stresses you are going to sort of put together. So a little match held up to the front is very different from a steam jet blasting the containment liner.

MR. KIRK: That is the other briefing.

MR. BANERJEE: Okay, I think I get the idea. I think if you concede that of course, then, the generalization is relatively straight forward.

MR. SHACK: That is what he is hoping to convince us of.

MR. KIRK: That is where I was hoping to get, yes.

MR. BANERJEE: This is sort of --

UNIDENTIFIED SPEAKER: I think we should go to conclusions.

MR. SHACK: Yes, quit while he is ahead.

MR. BANERJEE: Put it under advisement to think about it a bit. I get the general picture.

MR. KIRK: Okay. Well yes, let's got to the conclusions slide so Steve can talk. Well, I was one away, anyway.

No, we're next one, 35. Yes, okay. So then the next slide, which I think is my entree to Steve, so I have a few more to go.

So in the generalization study, our overall aim was to investigate whether the reference temperature screening limits which were derived from results like the ones we just shared with you developed for the PTS, for the three study plants, could apply to all PWRs in the U.S.

Our overall conclusion which hopefully Steve will help lead you to is that the PRA and TH characteristics did not need to be investigated or specifically checked for each plant.

So, if we go to the next slide, this is our overall summary of our model where we have a PRA event sequence analysis that defines the number, the things that can go wrong and the frequency of which they go wrong. The things that go wrong go into RELAP, which gives us pressure temperature and heat transfer coefficient variations of time, goes into a probabilistic fracture mechanics analysis and gives us a conditional probability of failure. That is then multiplied by the sequence frequency to get the yearly frequency of through-wall cracking.

So for generalization, essentially we have to ask for each of these major models, are there things, are there aspects of these major models that are somehow we expect to be radically different, different enough to change the bottom line answer in the population of plants in general relative to the three study plants.

MR. BANERJEE: Mark, let me just interrupt you for a moment here. Why is it that the French and the Germans and so on are so concerned about these plumes coming? Are they stupid --

MR. KIRK: Now, well actually --

MR. BANERJEE: -- or do they know something?

MR. KIRK: -- that is a wonderful question and I am glad you asked it because I had the pleasure of spending last week at the IAEA Headquarters in Vienna where, with my French and German colleagues I am writing an IAEA technical document on PTS analysis. And we have these continuing debates about are thermal plumes important.

So there are a couple of difference and no, they are not stupid because if I said that, they would never have a beer with me.

MR. BANERJEE: You couldn't write the joint paper.

MR. KIRK: That's right and we would never write a joint paper.

One is that, one reason is that they have a different, if you will, failure criteria than we have. Our failure criteria is through-wall crack into the vessel. So a preexisting flaw from fabrication needs to initiate and propagate all the way through to breach the vessel for us to count it as failed. Whereas, their failure criteria, I think, it is safe to say uniformly through Europe is against crack initiation.

The argument that --

UNIDENTIFIED SPEAKER: But you have preexisting cracks, how can they call it --

MR. KIRK: Against crack initiation.

MR. CORRADINI: Start the run.

MR. KIRK: Just to start the crack running.

MR. CORRADINI: But no, they don't worry --

MR. KIRK: Once it starts, they don't worry about it.

MR. CORRADINI: If it starts to run, you

are dog meat.

MR. KIRK: And the argument that I just made that thermal plumes generate predominately an increase in axial stresses creates a very large uptake in the crack initiation probability because it can initiate all the circumferential flaws. So, since they have a different failure metric, well they really should be worried more about thermal plumes.

But the other things is to take the -- I'm not so sure the French are so worried about it but certainly the Germans are. For the Germans, their materials, well first off, they have old Siemens and AREVA plants which tend to have very low fluence in the reactor belt line anyway. And their plants tended to be built later than ours, so they generally had better materials.

So their belt lines are in general not as embrittled as ours. And what they were finding in doing their analysis of the belt line, was very low failure probabilities. Well, they don't calculate their probabilities because they tend to use a deterministic approach but very low, I have trouble not using a Germanist word. They didn't think it would fail. And so their helpful regulators redirected their attention to failure from nozzle corner cracks.

So now if you read the current literature coming out of Germany, there is a lot of focus on the analysis nozzle corner cracks, where we were saying before from the APEX experiments, when you are getting injection into the pipes that lead into the nozzles, of course, the magnitude of the thermal plumes coming around that nozzle corner is very much, much greater than it ever is when it gets to the belt line. And since they are now concerned about assessing nozzle corner cracks, they have to consider that.

So they have, they are posing --

MR. BANERJEE: Is the French situation similar?

MR. KIRK: The French situation --

MR. BANERJEE: AREVA seems to worry about it.

MR. KIRK: Well AREVA is both German and French.

MR. BANERJEE: Yes. So it is the Siemens part which is breaking off now?

MR. KIRK: Yes. If I told you I understood the French assessment method, I would be generally lying. But perhaps the other reason is that unique to the French, they worry a lot more about subclad flaws than any of the rest of us do. And if subclad flaws exist, they exist everywhere. So, they are likely to be higher up in the belt line where they had seen more Delta T across the plume, if you will.

MR. BANERJEE: If our concern is because the belt line is the limiting worst case, anyway for us.

MR. KIRK: Because the belt line is --

MR. BANERJEE: By then all this stuff is dead.

MR. KIRK: Yes, because the belt line is more limiting and because of our election to use through-wall cracking as a failure criteria and not crack initiation.

(Missing audio.)

MR. KIRK: That's right. That's right. But I could also point out that they have an ability to be more conservative because generally their materials are not as embrittled. For example, the French have all forged rings. They have no axial welds. They have no axial walls.

MR. BANERJEE: So we need this rule.

MR. KIRK: This rule. We need this rule. Yes, I think so.

Okay, so if we went to the next slide, what we want to point out here is that for each and ever one of the major technical models, we have essentially posed to ourselves and tried to answer for ourselves and you and the public the same question which is, in the case of PRA, are the PRA-related plant characteristics that affect the bottom line analysis results similar in our three study plants to the population in general?

And the same question if we go to the next slide is posed with regards to thermal hydraulics.

So in the generalization study on the next slide, what we did is we compared the results from our detailed study plants, which we have been talking about so far, Beaver Valley, Oconee and Palisades, to five more plants. Now, we didn't just go into the hat of PWR's mix evenly and just pick the first five that popped out but we focused our attention on five more of the higher embrittlement plants, on the basis that say we had a situation at Palo Verde, which is a very low embrittlement plant where the incidence of PTS was somehow much, much greater or the severity of PTS, if it happened, is somehow much, much greater. Quite frankly, that is not really much of a concern because we know the material isn't embrittled.

So that is why we focused on these five plants because if there were differences in the frequency of challenges or the severity of the challenges, it would be most important if it occurred in a higher embrittlement plant.

MR. BLEY: My question on the table that as you go through your presentation, maybe you will address. Don't try to answer me this minute. Historically, when we have tried to take a PRA for one plant and pick up another plant and say well, this system is a little different, this is a little different, this other things is a little different, here is the new results. When we have actually done the PRA for that second plant, the results haven't aligned very well. Lots of things weren't quite the same and got complicated through it.

MR. DINSMORE: Right.

MR. BLEY: I am suspecting there are some reasons why maybe we are more optimistic here. And so if you will lean on those as you go through, I would appreciate it.

MR. DINSMORE: I certainly will try. There are some reasons and we will roll by them and if you are not happy at the end, we will revisit it.

Let's see, where were we? Okay, this is

the slide. The through-wall cracking frequency is the product of the frequency of the sequence and the conditional probability of failure, given the sequence. So what we did or what they did is they split the problem up. They are going to look at what could be changes to the frequencies of the sequences and what could be changes due to different thermal hydraulic characteristics of the plants, like the temperatures in RWST and that kind of effect.

MR. BLEY: Let me sneak in another question because I hadn't been familiar with this study. There is a lot of names on the cover where the PRAs had just two or three names on the cover. I am wondering were there a lot of calculations here or was it kind of a round table discussion sort of thing that led to this report or are there a couple of these people who really did the work?

MR. KIRK: This generalization report?

MR. BLEY: Yes.

MR. DINSMORE: The generalization study, part of the answer to your question, your very first question is the generalization study was, in my opinion, it was fairly well done. They really went out and they tried to figure it out and they came to a conclusion. So sometimes you see generalization studies where people start kind of with the assumption that it is going to work and then they try to prove it works. And sometimes those are not that great studies. But this one actually went out and tried to figure out what was important and they sent the questionnaire out to five different plants and they got answers from all the plants. And they went through it and they did a lot of work on it.

I guess it is only -- I wasn't involved in any of this.

MR. BLEY: Okay.

MR. DINSMORE: So I can't tell you personally what happened. And most of these guys are all retired and several of them are --

MR. BLEY: Well the two who did the PRAs or most of it, I know are retired.

MR. DINSMORE: And you can't get a hold of them anymore. Which is all right because this documentation has to support this process for the next 30 years.

MR. BLEY: We get an independent view now.

MR. DINSMORE: Okay, so we are going to address the two questions somewhat separately and then we will come back and put them back together. The first question was the frequency of these transients. And for the frequency part, the question is do the important sequences increase. In other words, do the dominant sequences increase in frequency? Because that could directly affect your result. And the second part of that is are there any unimportant that could somehow come drifting up because of things in the plants.

MR. BLEY: Things that weren't important in the three studies that could --

MR. DINSMORE: Become important, yes. So that is the overview of the frequency part. And although mark said I was going to do TH and PRA, I am going to do PRA and then TH with a lot of help from Mr. Eseery (phonetic) I hope.

And so the severity of the PTS challenge is the second part. And the first similar question there is do important transient classes have the same or higher severity? In other words, if you had kind of the same scenario at a different plant, would the conditional probability of failure be much higher for that sequence? Well, for the dominant ones could it be higher and for the non-dominant ones, could it be much higher so that they would come up? So, it is the same idea for both types of studies.

MR. BLEY: And that would include the

degree of embrittlement you expected at those five plants.

MR. DINSMORE: No. The degree of embrittlement was only looked at for the one scenario where they wanted to further study the interaction between two. So the conditional probability of failures were done at 60 FPY, I think is probably the best answer.

MR. BLEY: That is a good answer.

MR. DINSMORE: Yes. So, then if we go to the next slide, we will start off here.

The report you are looking at is the Generalization of Plant-Specific PTS Risk Results to Additional Plants. It is dated December 14, 2004. It is also summarized in Section 9.3 of the main report and it, again, it compares both key PRA and thermal hydraulic characteristics.

Go to the next slide. Okay, these are the data -- the PRA part I will deal with first. What they did is they identified five general PRA event scenarios and they evaluated them for differences between the plants. And the scenarios that were secondary, breach is secondary, overfeed, medium and large LOCAs, PORVs and SRV-related and feed and bleed related.

One thing you have to keep reminding yourself, especially if you are a PRA person. These are not core damage sequences. These sequences stop either when you get to a PTS event or you avoid it. And the best example from that is these large and medium break LOCAs because the switch over to recirculation is not important. I mean, it doesn't matter what type of recirculation equipment the plant has. To get to that point, you are not going to worry about PTS anymore. If you fail to switch over, you are going to go to core damage. And if you switch over, then they actually did look a little bit about the thermal hydraulic consequences of switching over, if you started pumping real cold water in there. But there is no more change to the frequency. It is the frequency you get to this point.

UNIDENTIFIED SPEAKER That created an odd situation when you read the PRA. Isn't it some failure that help PTS could get you into core damage trouble but they don't matter because they weren't PTS.

MR. DINSMORE: Right.

UNIDENTIFIED SPEAKER: It's just a little quirky when you read it.

MR. DINSMORE: But again, this was to take care of the PTS problem. Okay.

So anyways, so some of these sequences are kind of truncated for PRA people. And that is one of the reasons that made life a little easier to compare the plants because it was kind of the front-end of the sequences is the only thing you are looking at.

And another thing you might note, which I noticed immediately looking at this slide, there are no small LOCAs. I believe the small LOCAs that are small enough to re-pressurizing using high pressure injection at the PORV set points, are pretty much covered by the feed and bleed scenarios.

And those in the small LOCAs that can't re-pressurize, are probably bigger than the two inch bottom limit of the medium LOCA. So even though small LOCAs doesn't keep showing up like one would normally expect, it is kind of included in the sequences.

So what I will do is I will go through each one of these kind of quickly. Secondary breaches. Secondary breaches are, for example, feed line break. These scenarios stop when excessive cool-down is avoided. They include MSLB and all valves, spurious openings for like steam generator SRVs or the failures to close the TBVs. Anything which would result in the uncontrolled release of steam.

The PRA itself that looked at the operators and plant systems that were needed to isolate the breach, if possible, and/or isolate the feed to the steam generators, and they also looked at the proper steaming of any remaining steam generators because of the potential to re-pressurize the primary if it wasn't done properly. So that was kind of the general scenario they were looking at. And so what they did was they put together tables which are in this report and they identified specific issues and I just pulled a couple of them out for each of these slides.

So they looked at the, they asked all of the five extra plants about how the operators could identify the faulted steam generators. And the procedures that they had to feed the faulted -- isolate feed from the faulted steam generators and procedures for proper steaming of any remaining good steam generators.

And they concluded that the lack of AFW isolation at some units might increase the frequency of excessive cool down because they were pumping too much water in but that operators had multiple opportunities to identify and isolate the faulted steam generators.

There is a lot of operators in here, which is why we had these big discussions about how much the operators are contributing. And so they effectively concluded that these scenarios are not expected to be more important or to become important at operating PWR. And I guess I skipped the first bullet or the second bullet.

This is not really an important scenario either at high or low embrittlement but it is always something that people keep in the back of their minds to figure out how far they are going to pursue these different problems.

So, and then the next one --

MR. SHACK: Well, I mean, it is not an important scenario in the three plants.

MR. DINSMORE: And it would not --

MR. SHACK: Now the conclusion is it wouldn't become important any other PWR.

MR. DINSMORE: Right.

MR. SHACK: Thank you.

UNIDENTIFIED SPEAKER: Because of the five plant study.

MR. DINSMORE: It was not important so the aim was to make sure it didn't become important.

MR. SHACK: This is one that you avoid creep.

MR. DINSMORE: Right. Then the next slide. The next slide has two of the five on it. Secondary overfeed, that was not an important scenario at low or high embrittlement. So we are just making sure that there is no increase. This scenario also stops when excessive cool down is avoided.

Now here the scenarios of the uncontrolled and excessive feedwater flow without a breach. Anything like MSLB or SRVs, secondary SRVs sticking open would be treated by the other one. This was just the operators were severely overfeeding the steam generator and actually the Duke scenario that they talked about was the most severe, which was effectively the plant would trip with the failure of the main feedwater runback. And what they eventually modeled was filling the steam generators to the highest level you could fill them and just holding them in there and letting the steam off.

MR. BLEY: And that is of ones through steam.

MR. DINSMORE: Yes, Oconee was the one. A lot more boil off, I guess.

MR. BLEY: Yes, you fuel the transient

faster, I guess.

MR. DINSMORE: Yes. But again, what they effectively did is they did not identify any PRA issue because it was very unlikely is effectively the way they dealt with this one. If it was going to be a secondary breach, it was treated in the other one. But this was simply that the operator somehow kept feeding the thing too much. And so they didn't really --

UNIDENTIFIED SPEAKER: Was there a test case on that at all with the favor? Does that turn out to be something that would be challenging? If generators are overfed using the normal --

MR. SHACK: Isn't that the Duke transient?

MR. KIRK: That is the Duke transient. So, yes we did.

MR. SHACK: You did.

MR. KIRK: And at the screening limit, that is what Matt was saying, it was a ten to the minus eight contributor.

MR. BLEY: That makes more comfortable than the other arguments.

MR. DINSMORE: But it was a pretty high CPF. It just had a very low, had a low frequency. I'm sorry, conditional probability of failure.

MR. BLEY: Oh, okay.

MR. DINSMORE: Then the next one of the five general scenarios was the medium and large LOCAs. These were not important scenarios of low embrittlement but have become important and actually dominated the high embrittlement. And these scenarios are fairly --

(End of Tape 2, side 1)

(Begin Tape 2, side 2)

MR. DINSMORE: Conclude that there is really not much the operators can do in this situation. But if they get a PTS right up front, they either get it or they don't.

MR. BLEY: How did you convince yourselves, you weren't in on this, how did they convince themselves that, especially the medium LOCAs couldn't be substantially due to seismic? Did some look at that?

MR. DINSMORE: Another advantage to this, impressive about this study is every time somebody came up with a question like that, we could find a report that dealt with it. There is a report that deals with it. I have a bunch of backup slides.

MR. BLEY: For the five plants?

MR. DINSMORE: For the five plants and all external events.

MR. BLEY: Yes, I mean it is a generalization of the seismic studies, right.

MR. DINSMORE: Right. Let's see, for medium and large LOCA, what they effectively, for the seismic, these --

MR. BLEY: Medium LOCA is the one I am particularly asking. That large LOCA, it is hard to see how you --

MR. BENSON: Three G is what they --

MR. DINSMORE: Three G.

MR. SHACK: No, for the large. The big earth.

MR. BLEY: But in some plants that I have seen analyzed for seismic, there have been kind of unique things like the way the surge line was supported, things like that, that begin to get into some trouble. And if you don't look plant-by-plant -- in this external event study, did they look plant-by-plant for sort of things that could cause a medium LOCA that was affected to the fragility of the supports? And if not, I wonder why we are convinced it is okay.

MR. DINSMORE: Well the external event analysis was done effectively by identifying a bunch of scenarios and then putting bounding analyses on them.

MR. BLEY: How do you bound them if you don't look at the fragilities on a plant-specific basis?

MR. DINSMORE: Oh, well they bound it by using, they used, for most cases they used the Diablo hazard curves.

MR. BLEY: Yes, but what did they use for fragilities for things like the surge line, like?

MR. DINSMORE: For the large and medium LOCAs, they used the heat cliff of 3.6 G.

MR. BLEY: Were did it come from?

MR. DINSMORE: Well, actually we looked at --

MR. BLEY: 3.6 Gs?

MR. BLEY: Yes, that is the large break LOCA. For the small break LOCA they did like a 0.3 G.

MR. DINSMORE: Small LOCAs is 0.3, yes.

MR. BLEY: You know, in the eastern plants, they did 0.5 at Diablo, figuring that everybody had designed their piping at least to that sort of design-basis level. Then I think the argument comes in with that and the frequency of the earthquake.

MR. DINSMORE: Yes, it is also confusing between small and medium. The smaller, for the small ones it was 0.3 G and for the mediums, I think a medium is 4 and up but they had 2.

MR. BLEY: They just put in the middle between the three they had for the large and the --

MR. BLEY: I guess my point is, especially for the medium LOCA, without looking at the way the plants supported the way the arrangements are precisely in that plant, how do you just pick a number like 2 G out of the sky say that is bounding?

MR. DINSMORE: Well I am afraid, I'm not sure that you would have much more luck going into a particular plant and developing --

MR. BLEY: Well I am sure that some people who do the fragility for a living --

MR. DINSMORE: I'm sure they would disagree.

MR. BLEY: -- would walk into the plant and do a lot better than we can sitting in a room.

MR. DINSMORE: When we see the numbers coming through, they don't seem to vary that much. Now, seismic PRA is one of the not well laid out, fires is kind of halfway there. So seismic PRAs are not complete and we have to kind of keep moving along with risk-informed techniques. So we kind of have to use the best available information.

And I guess if you are saying that the best available information currently out there in the industry, maybe it is not percolated back here but there are major differences between plants as far as the ability of a medium sized piping to withstand earthquakes such that the initiating event frequency from a seismic-induced a medium --

MR. BLEY: Not the initiating event frequency. The conditional probability of failure giving --

MR. DINSMORE: No. It has to -- well. See, what we are comparing it to is the initiating event frequency of the medium LOCA just --

MR. BLEY: Why don't you go on. I don't think we are going to --

MR. KIRK: Well, one other thing they did bring up was that the IPEEE guidance to the utilities allowed seismically initiated large and medium LOCAs to be screened from analysis, indicating they were considered unlikely. So that was the conclusion at that time.

There is a number of arguments they have in here. But they are, as Steve said, they are trying to be bounding here. But they are looking back at what everybody has done for this stuff.

MR. DINSMORE: Yes, and if the seismic-induced frequencies is not substantially or is not larger or substantially the same as the internal event frequencies, that would be enough for us not to have to go look at each individual plant, if we thought that was generically true.

MR. BANERJEE: There is no synergism between the cracks.

MR. DINSMORE: You mean the cracks in where?

MR. BANERJEE: Shake them up, nothing happens?

MR. KIRK: If you can shake this sucker.

MR. BLEY: You can shake the earth and they --

MR. BENSON: Lots of things will fail in the plant long before this vessel ever goes from the earthquake.

MR. BANERJEE: All I was saying was something which can lead to a medium break LOCA, can it do anything to existing cracks?

MR. DINSMORE: No.

MR. BANERJEE: Are you sure of that?

MR. KIRK: Don't look at me.

MR. BANERJEE: You are going to break a pipe somewhere due to this earthquake.

MR. KIRK: There is a difference between the section stiffness of a pipe and the section stiffness of a pressure vessel that is multiply supported. I mean, yes. I can't tell you I have done the analysis but I --

MR. BANERJEE: Unless the support breaks.

MR. KIRK: If it takes 3 G to break the large pipe, it is going to be a big earthquake.

MR. BANERJEE: You would probably break a support or something.

UNIDENTIFIED SPEAKER: On the vessel? I don't think so.

MR. BANERJEE: A nozzle?

MR. KIRK: It is of less concern because everything else is going to be dead in the plant.

UNIDENTIFIED SPEAKER: It would take some support giving way and something moving a lot.

MR. BANERJEE: But the scenario that you are postulating is a medium break LOCA with your seismically --

UNIDENTIFIED SPEAKER: If you lost the steam generator support, you might break a nozzle.

MR. BANERJEE: -- generator. So if you are going to generate the medium break LOCA seismically, then you have other things that happen. The question I am asking is, what else happens with the earthquake.

MR. DINSMORE: Oh, you could lose all kinds of equipment but we are just --

MR. BANERJEE: But I mean related to PTS.

MR. DINSMORE: Oh, PTS.

MR. BANERJEE: Is there anything that happens there, any potential synergism?

MR. KIRK: You probably have lost your capability to inject cold water at that point because nothing is working.

(Laughter.)

MR. KIRK: Core damage might not look good, but you ain't going to bust the vessel.

MR. BANERJEE: Well, you might have a more serious problem.

MR. BLEY: Well you know, that may well be true of the other one I brought up.

MR. BANERJEE: A different five.

MR. KIRK: Yes, by the time you are busting those pipes.

MR. BLEY: They saw this on one example

from the past and I know nobody, not every plant has had a thorough fragility analysis. In fact, it is a very small number.

UNIDENTIFIED SPEAKER: In many of the fragility analyses, if one looks closely, one --

UNIDENTIFIED SPEAKER: Well a lot of the fragility guidelines they have have seriously been called into question by the Japanese earthquake because the list that we used for the IPEEEs seems like it has almost been inverted compared to the results. You know, things that we thought would fail like crazy just didn't fail. And all things that we thought were low on the list did fail. I mean, it is just not obvious that we know what we are doing.

MR. BLEY: See, I only have one example of a fragility analysis I had done that actually suffered an earthquake later. It turned out to be surprisingly, very surprisingly accurate.

It was at a microelectronics facility at Stanford University. It was a quarter G earthquake and things that were predicted to break had just started to yield.

UNIDENTIFIED SPEAKER: Is that the saleenik (phonetic) insulators?

MR. BLEY: Now, that is a good question. I can't remember what it was. It was the one that hit about a quarter G near Stanford. So it was before, I know it was before '94 because I was still at my other job.

MR. DINSMORE: Okay, I guess then that result mostly the medium and large LOCA. So let's go to the next slide. Oh, you are already there. Okay.

MR. KIRK: Somebody keeps us on track. Good heavens. Quit that.

MR. BANERJEE: She is trying to get us out of here.

MR. DINSMORE: These are PORV and primary SRV related. And as we keep saying, these are important scenarios at low embrittlement but they become unimportant at higher embrittlement, as other scenarios become dominant.

These scenarios start with a PRV or an SRV failure. Either just they fail or possibly due to following a normal trip. The scenarios include failure of system or the operator to avoid excessive primary cool downs and/or cold repressurization. For example, failures which cause excessive, well, the operators fail to appropriately control main feed or auxiliary feed or they fail to throttle the HPI, which could lead to cold repressurization or the SRV re-closes. Those are also in here.

They investigated the number and sizes of the PORVs and SRVs, the capability to identify stuck-open valves. Procedures for coping with stuck-open valves and procedures for coping with sudden stuck-open valve re-closure. They concluded the differences in the capability to identify stuck-open valves might increase the scenario frequency but not enough to make the scenario important at high embrittlement. Therefore, these scenarios are not expected to become important at any operating PWR.

The last one of these is feed and bleed. Feed and bleed tends to be an unimportant contributor at all levels. The scenario is effectively a transient followed by a loss of secondary sight cooling completely. So you eventually have to implement the feed and bleed. They investigated the capacity of secondary feed as failures would lead to feed and bleed to procedures directing the implementation of feed and bleed, the number of PORVs and SRVs for bleed, HPI systems for feed.

And they concluded that the likelihood of losing secondary feed might be different between plants but not enough to make the scenario important at any operating PWR. They were coming up with numbers like five, ten, fifteen. It might increase the scenario frequency by five or ten. But when you take that back into the numbers that Mark was talking about, those were only for the unimportant ones and the important ones weren't increasing or they couldn't find a reason that they would have increased.

MR. BLEY: I guess -- I'm sorry. I like the approach they took for what they are trying to do. I am a little nervous about it not working. I don't know quite how well those surveys -- I don't see the actual surveys and like how well they cover it. So, I am a little nervous about it but it sounds right.

Seismically induced events on the medium LOCA and some things like PORVs and SRVs, depending on how they are specifically mounted would lead me, without having looked at that, unless the questionnaire said send us photographs of how those things are mounted.

MR. DINSMORE: Well the seismic, they address the PORV seismically as relay chatter with 0.3 G or something. And then --

MR. BLEY: I'm happy with that part of it.

MR. DINSMORE: Okay. We are only left then with the seismic medium LOCAs that you are kind of unsure.

MR. BLEY: Or small LOCAs associated with valves that could, that are mounted in an unusual manner that might be vulnerable.

MR. DINSMORE: To an earthquake?

MR. BLEY: I think SSMRP identified some valves in that position in the plants they looked at. I forget what it was. And I know a few other seismic PRAs have found a valve here or there. It doesn't take more than one. So, if you don't actually look, you don't know if there is something funny.

MR. KIRK: But again, a small break LOCA is not a big contributor for a PTS.

MR. BLEY: Well, it looks a lot like the stuck-open safety valve which was there.

MR. KIRK: Which isn't really important at the level that we are talking about.

MR. BLEY: It was 20 percent of their total.

MR. KIRK: Well, in this sort of thing, 20 percent --

MR. BLEY: If you don't care about 20 percent, the other 80 you don't have to worry about either. If you have 20 percent and you don't care about factors of four, right?

MR. DINSMORE: At 60 EFPAs, the total CDF that they were estimating was about one times ten to the minus eight.

MR. BLEY: Based on some initiating event frequency.

MR. DINSMORE: Yes, for each of the plants, the three of them. Yes, this was just a 60 EFPA. We keep talking about what dominates win which is always confusing in this situation.

MR. BLEY: Now if the hazard curve for these plants and there are some hazard curves for different locations which show that the likelihood of an earthquake, you know, you might make an argument based on the hazard that might be at a plant that it has to be lower than the initiating event frequency for the similar internal event. They do that.

MR. DINSMORE: Okay, but they --

MR. BLEY: I don't see the seismic --

MR. DINSMORE: Well the seismic is a completely different report.

MR. BLEY: I know it's not in their report.

MR. DINSMORE: Yes.

MR. BLEY: I don't, without having looked for something that is an unusual configuration, I am not comfortable there might not be one. Because usually those things don't matter very much to the seismic events but once in a while there is one that is mounted in an odd position with an odd mounting arrangement that is vulnerable. It is fixed but it is vulnerable until you find it and fix it. And if you haven't looked, the generalization study approach seems suspicious to me with those kind of things.

You have kind of convinced me that except for things like medium LOCAs or good sized small LOCAs, you are probably okay. On those without having looked for --

MR. DINSMORE: See we placed a bit of the difficulty that we would have to tell them, we would have to tell them to look at this.

MR. BLEY: Well, they have already looked. And did they do plant-specific, what do you call, either one of the seismic, either a seismic PRA or a margin study? If they did, they probably searched for things like that. They did a walk down.

MR. DINSMORE: Who is they?

MR. BLEY: The owners of the plant.

MR. KIRK: When they did the IPEEE.

MR. DINSMORE: Yes, they probably did the walk downs for the IPEEE.

MR. BLEY: The walk downs should have identified if there was something unusual but you didn't look at the walk downs.

MR. DINSMORE: But we would have to tell them when they implement this rule and tell us to go look again. You would have to rise to that level.

MR. BLEY: The underlying assumption here is that the generalization study and the associated external events study shows that there is no one plant that might come under the rule that might be susceptible to a higher frequency of medium or large LOCAs, well say medium LOCAs, or I will say large small LOCAs but a couple of things like that showed up on your list, aren't sitting there waiting for the seismic to get --

MR. DINSMORE: Which would increase the frequency of one of the dominant scenarios. That is what you are -- well, again, the only --

MR. BLEY: I will go back and look again at that external study.

MR. DINSMORE: The action we would have to take would be --

MR. BLEY: But it doesn't sound like a comfortable feeling with that. We are not going to solve it here.

MR. DINSMORE: Well we will talk about it, I guess.

Okay, then I guess, these were the general PRA scenarios. And then as we go on to the thermal hydraulic scenarios, there were four general classes which were identified, which were the large LOCAs, the medium LOCAs, the stuck-open primary valves that re-close, overcooling primary by secondary.

Now here, they were looking at the thermal hydraulic stuff that goes on with these sequences. Earlier, they were trying to figure out what the frequencies were for getting into those scenarios. And here they were looking at the flow rates and the temperature of water flowing in.

Now, I am kind of out my depth here. So, if anybody has questions, you can ask Bill.

First of all the large LOCAs, will go straight to the second one.

MR. ARCIERI: Do you want me to just talk?

MR. DINSMORE: Yes, if you are willing.

MR. ARCIERI: I'll just take you through it.

MR. DINSMORE: All right.

MR. ARCIERI: All right. Like Steve said, we basically subdivided thermal hydraulic space, if you will, into four groups. The first group was large LOCA, basically, LOCAs over eight inches in diameter.

The second, medium. Medium in our categorized to what I would call smaller LOCAs which went from 5.7 inches and less. Stuck-open primary valves that re-close, these are repressurization transients that we have been talking about. And overcooling of the primary by the secondary due to something like a main steam line break.

The case of the large LOCAs, what the analyses have shown, this is the entire analysis through the Fracture Mechanics is that it is a generally important contributor that becomes controlling at high embrittlement.

Now, when we did the subdividing of LOCAs, we looked at LOCAs where you would basically have a break of a size where you had, basically, were transitioned through critical flow very quickly and at your pumps, you know, your HPI, your LPI, and your accumulators would basically just discharge into the system and cool everything off.

The pumps would generally be running at almost run-out conditions. Certainly the HPI would be at run-out conditions. The LPI would be at almost run-out conditions. They would be maximizing your flow. The temperature would drop very rapidly and if you were to have temperature-induced failures, they would occur, I think fairly quickly, usually within ten or 15 minutes, I think is what favor had showed. So it was a very defined scenario and it was eight inches or greater.

The smaller breaks, less than say 5.7 inches, what we found is that they are critical flow limited so that your pump break, your accumulated discharge or your pumping rate is basically determined by how much flow you can pass through the break. And in that case, there is some dependence between the things like the size of the system, you know, volume of the system, for example, the power level, and generally the size of the system scales to power level. Basically those two things.

And in the case of the four to five plants that we looked at, they have a higher power level. So if anything, you would expect the temperature and depressurization to occur more slowly in those plants. The notable exception is Fort Calhoun and we will talk about that maybe a little bit more at the end.

The third case is the stuck-open valve that re-closed. Basically, these valves, they sit on top of the pressurizer. They have an orifice diameter in the one and a half to two inch range. And you will see a long bound transient until the valve basically re-closes. And then, you know, it is just basically the characteristics of the HPI that come in and just drive that system pressure right up to the setpoint of the relief valves.

In this case, there were some differences, of course, in valve sizes. Four to five plants again had a higher power level so you would expect them to have a somewhat higher valve capacity.

MR. BLEY: Does it matter much you have almost a factor of two difference in that ultimate pressure, depending on what kind of -- there are some that will got up to about 2500 PSI and others that will go up -- Does that make any difference?

If you remember at the three plants that we looked at --

MR. ARCIERI: I'm not aware of any plants that have an HPI shutoff as low as 1500 PSI.

MR. BLEY: They all say at centrifugal pumps that went up to 2600. And some plants don't have the high head centrifugal charging pumps. So there are some that --

MR. ARCIERI: Okay.

MR. BLEY: So you were looking at all of whatever you tell us is based on the higher pressure. Okay.

MR. ARCIERI: I don't think I had anything more to say about the stuck-open valves. I guess we can move on to the overcooling of the primary by the secondary.

In this case, --

UNIDENTIFIED SPEAKER: Well is the stuck-open valve what causes you pause in connection with the AP1000? At the beginning, you told us that none of this applied to AP1000.

MR. MITCHELL: Well I would simply say that I think the original comment was more of a general statement is just noting without going into specificity as to why the AP1000 is different is just that it was a notably different design that has not been, that we did not feel was thoroughly analyzed sufficiently such that we had a good handle on event frequencies and severities that we wanted --

UNIDENTIFIED SPEAKER: It is not a PRA.

MR. MITCHELL: Understood. But for the purposes of ensuring consistency with the PTS tech basis, to extract that information and to actually sit down and consider it, --

UNIDENTIFIED SPEAKER: You just hadn't done that.

MR. MITCHELL: Just hadn't done it. And it didn't seem like it was a necessary step to extend it out to that at this point in time to prove the utility of the rule.

MR. KIRK: But it just also seemed very unlikely to need it, I mean, as you pointed out. I mean, you are going to start with a brand new ring forged vessel.

MR. MITCHELL: With no copper. With no or low copper. We just literally didn't put the resources toward making that evaluation for a lack of an objective need for it.

UNIDENTIFIED SPEAKER: But it was not because of specific features, it is just because you hadn't looked at it.

MR. MITCHELL: Yes, we haven't looked at it. But as you know, there are certain features that we would want to look at more closely, if we did look at it.

UNIDENTIFIED SPEAKER: Yes, I mean, it is the vent valve system would cause you pause.

MR. MITCHELL: That would be certainly one of the differences.

UNIDENTIFIED SPEAKER: But it doesn't preclude you from doing the work in the future.

MR. MITCHELL: No, certainly, nor any licensee from doing the work in the future, if they need to demonstrate, wish to demonstrate.

MR. ARCIERI: Okay, the final category was the overcooling of the primary by the secondary. We looked at a number of things in this case, the size and location of the secondary break, flow restrictions that are available, and the operator action to isolate secondary side systems.

Not surprisingly what you find is that the scenario is bounded by the steam line break and it is a situation, I think, that is similar to the large break LOCA in that you are releasing all of this steam very quickly and the system will cool down. And what we found among the plants is that as long as you have some control over auxiliary feedwater, the secondary side doesn't go below, basically the saturation temperature of water, which is 212. And so you are limited to just how rapidly you will draw heat out of the primary system, though in this case, they are not as severe as in the case of the large break LOCA.

Now, we did find one outlier in all of this and that was Fort Calhoun. I didn't see any slides in here about the Fort Calhoun situation.

MR. DINSMORE: The last back up slide. We did put a slide together. Well, on the final --

UNIDENTIFIED SPEAKER: Before you leave that last one you had up there, it sounds like this includes the one that was talked about earlier, which was overfeeding. No plant had a much larger capability to feed than the other. I don't know of any.

MR. ARCIERI: I think that is correct, yes. We did always assume that there was the operator action to basically correct the overfeed. So we didn't allow the feeding to continue indefinitely.

UNIDENTIFIED SPEAKER: But that strikes me in a real mix on the part of operators and a few who are really concerned about overfeeding, others who don't seem at all in most of the procedures.

MR. DINSMORE: Are you finished with this slide?

MR. ARCIERI: Yes, I am.

MR. DINSMORE: Go to the -- this last slide, actually it also at least from my point of view provides a little more confidence also in the generalization study. Based on the results of this generalization study, they went back and made some changes or at least redid some calculations about what eventually went in the rule.

UNIDENTIFIED SPEAKER: The plants did.

MR. DINSMORE: No, no. We did.

UNIDENTIFIED SPEAKER: We altered the reference temperature.

MR. DINSMORE: See, there was no interaction between the PRA and the thermal hydraulic characteristics for the dominant, medium and large LOCAs. However, there was kind of this question about well you might have some interaction between PORV or RV frequency which actually could be higher because some of the plants either would get into that situation more often or they weren't able to deal with it as well.

And the TH response --

MR. SHACK: This is the factor of five to ten you were talking about before. Right?

MR. DINSMORE: Yes. So, either the frequency of the cool down could increase and you might get faster cool down for low power plants, which is Fort Calhoun.

MR. ARCIERI: Fort Calhoun was, it is a smaller plant, 1500 megawatts thermal or thereabouts. And it also had, I think, somewhat larger relief valves.

UNIDENTIFIED SPEAKER: Okay so it basically is a small plant with more than enough capacity --

MR. ARCIERI: With a lot of capacity, right.

So we looked at stuck-open valve scenarios in that situation and, as you might expect, the through-wall cracking frequency increased. And that consideration was incorporated into the rulemaking. So we did run into situations where and we did find an outlier in the case of Fort Calhoun.

MR. BLEY: That brings up a thought. You had said earlier on that, I think, no new plants are going to need to take advantage of -- are going to have any problems. But some of the new plants have (inaudible) steam capability much, much higher than any existing plants, like 150 percent would still be bounded by a steam (inaudible).

MR. MITCHELL: Although, I would say we do not have any specific calculations to prove it, I would say that the overwhelming improvements in the construction of the vessel, you are going to have new vessels with no axial welds. You are going to have single piece ring forgings. In a lot of cases, the elimination of copper. So, it doesn't even play a role.

PTS evaporates for those vessels. It just it can't possibly fail effectively. And I will probably regret saying those words.

(Laughter.)

MR. SHACK: It won't fail by PTS.

MR. MITCHELL: PTS would not be, it is like that earthquake, the vessel would not be your first concern.

MR. DINSMORE: Okay and then the summary slide that closes this up then would be that the PTS technical basis appropriately modeled the challenge type, frequency and severity in the study plants. And then the generalization study found that the study plants well represented the operating fleet. And that the conclusion was that the evaluations demonstrate that plant-specific PRA and TH evaluations are not needed to implement 50.61a.

And again, there is a fair amount of judgment in the generalization study but judgments aren't necessary in all different studies. And they did a very, I think they did a well documented job at it and they went through it and they did it systematically and they came to the conclusion and we have accepted it.

UNIDENTIFIED SPEAKER: That was done in 2004. How long did it take for the staff to conclude that was right? They had these medium to large break LOCAs on a high embrittlement plant.

It's big news to me. That is why I am asking.

MR. MITCHELL: I guess if I am going to field that, I would ask to restate the question.

UNIDENTIFIED SPEAKER: This study was done several years ago.

MR. MITCHELL: This study being specifically?

UNIDENTIFIED SPEAKER: The generalization study.

MR. MITCHELL: Okay.

UNIDENTIFIED SPEAKER: And someone who doesn't spend a lot of time on worrying about PTS, the conclusions are pretty dramatic, I think. Really the only thing that matters are medium to large break LOCAs in high embrittlement plants. And I just wondered, when did the staff just basically come to that conclusion. In the last year or so or has that been around for a long time?

MR. MITCHELL: Well I think it has been sort of a continual outgrowth of the results we have been getting from the favor analyses that have supported this observation, which is distinctly different from the old days, from 50.61 where the classic PTS scenario was small break LOCA stuck-open valves.

Now with fact that we were using this more realistic flaw distribution requires that you have these more severe loading transients that come with the medium and large break LOCAs, the extraordinary thermal loads that then allow them to trip and actually fail the vessel at the higher embrittlement rate. So, I don't know when was the first time we looked. We noticed through the favor runs that it was medium and large breaks that were dominating but it was sort of progressively along the way.

MR. KIRK: Well, I think -- one of my lessons is it takes, I mean, if you say when did the staff, I mean, it sounded like Bill Clinton and define the staff.

UNIDENTIFIED SPEAKER: No, as a group of specialists to conclude and say hey, this thing is real.

MR. KIRK: In 2004, the research team that worked on this, which included Bill, Dave, myself, many, many others, I mean, we wrote NUREG 1806 and it said essentially that because NUREG 1806 drew on the study that we have been discussing here in detail. We shared it with whoever was on the committee in 2004.

Since that time, it has been, I mean, we have gone through the rulemaking process, which involves the group that prepared the technical basis work. Well, first off, selling it enough to our colleagues at NRR for them to sell their management to under a rulemaking to give it a high priority, and then the staff there needs to be comfortable with it, and then it goes out for public comment and so on.

So I guess one of my lessons here is there is a lot of people that need to get on the bus comfortable with the idea and especially when there are some things that aren't like what we thought we knew before, where we is the global we. It takes some time.

MS. RODRIGUEZ: Yes, I would say that in the active rulemaking phase, we have been working on it since 2006, 2007 time frame. And nowadays we don't publish rulemaking plans but at that time, we issued one and that takes time. And in 2007 --

UNIDENTIFIED SPEAKER: It is likely to be the conclusion of your --

MS. RODRIGUEZ: Right. And so in 2007, the Commission said hey, go ahead and issue a proposed rule. You have enough information here to do it.

So this concludes our presentation. If you have any additional questions, we will be happy to answer those.

MR. BANERJEE: What are we going to do, Bill? Are we going to write a letter?

MR. KIRK: I'm planning on writing a letter, if I can get my colleagues to support me.

UNIDENTIFIED SPEAKER: Whoever said everything wonderful about this study so many times, what we going to say now?

We have complimented their intelligence, their purpose (inaudible) diligence. What now are we going to say?

MR. KIRK: Well, the only real remaining question is the generalization study. As you have said, we have blessed the three plant study more times than you care to think of. But we now have the question of have they sufficiently addressed the generalization issue that the only thing, I mean, they clearly on a plant-specific basis, they have to evaluate the embrittlement, because everybody's 60 years are not equal.

And I sort of agree with them that the thing here that is the greatest uncertainty is what this flaw distribution is. And so they are out to verify that.

UNIDENTIFIED SPEAKER: That is not what I would call a breakthrough in your thinking. You have been pretty consistent on that since the day I met you.

MR. KIRK: You know, and so that has to be verified on a plant-by-plant basis. You know, the question is, is how convincing do we find the arguments that we don't really have to look at the event frequencies or the thermal hydraulics on a case-by-case basis.

UNIDENTIFIED SPEAKER: Yes, I would say that the most surprising aspect of the whole PTS is how little variation there is in the thermal hydraulics.

MR. SHACK: Yes, I mean, if you just look at his curves where he has plotted the three plants, they are all sitting there.

UNIDENTIFIED SPEAKER: Yes, but that is the continuation of a long string of evidence that showed it almost from the start of the study. I mean, as soon as you got into it, you had anticipated this huge effort from thermal hydraulics and all of a sudden you were finding, well, maybe we don't have to knock ourselves out here.

MR. KIRK: But I mean we do a B and W, we do a combustion, we do a Westinghouse. I can't normally get my data to sit on a curve the way those three in those analyses do.

UNIDENTIFIED SPEAKER: None of this is surprising.

MR. KIRK: RELAP is just canned to produce the same answers.

MS. RODRIGUEZ: This is a very, very informed rulemaking and hopefully you would only have good things to write in that letter, hopefully.

UNIDENTIFIED SPEAKER: Oh, we will come up with something.

MS. RODRIGUEZ: I am pretty sure.

UNIDENTIFIED SPEAKER: I mean, clearly one of the big debatable issues is regulatory certainty drive to make the rule once again the same problem that we are trying to get rid of in all of the other rules. I mean, that is a very questionable approach to my mind.

MR. BLEY: Well if he had just said the lawyers made me do it, I would have --

MR. BANERJEE: How are you going to break the ACRS rule that you don't write two letters?

UNIDENTIFIED SPEAKER: There is no such rule. I have written up to four.

UNIDENTIFIED SPEAKER: No, there is no rule.

MR. BANERJEE: You made me write only one letter.

UNIDENTIFIED SPEAKER: You were new and I was trying to protect you.

MR. SHACK: You want to be allowed to write the COP letter?

MR. BANERJEE: No.

UNIDENTIFIED SPEAKER: Dennis.

MR. BLEY: Most of it, there are a couple of things that leave me uncomfortable on the generalization. The first is I come into it having a history of being foiled at trying to do things like the generalization study.

The narrowness of what is important helps a whole lot. It certainly hinges on (inaudible) code and everything out of that what seems to be a fairly complicated model was right on target and these things we weren't expecting to be important a few years ago are.

MR. KIRK: Well, we certainly are generalizing favor but all the plant-specific PRA studies aren't going to change favor at this point.

MR. BLEY: They're not. But two things on the seismic leave me troubled and they are related to three things. The odd mountings of things that weren't looked at separately, any interfaces between structures that could damage pipes, but that is probably not going to get us on the LOCAs. And the two over one issue that I hope has been resolved but I have got to think about that one a little. Fires could also get us on a few RV but I think that is low enough that it is not a big deal.

I guess the last thing is in looking at five plants in the generalization study, you made two changes, I think. Now we are going to apply it to everybody. I am not completely convinced that we have really generalized. I have to think more about this.

MR. DINSMORE: I'm sorry. What you meant by two changes.

MR. BLEY: Well you talk about two changes that were --

MR. DINSMORE: Oh, to the rulemaking.

MR. BLEY: Yes, to the rulemaking based on looking at five plants as well as you could in the generalization study. But if you had looked at ten or twenty --

UNIDENTIFIED SPEAKER: But even if you changed the probability of the current seismic events or fires or what have you, it doesn't change the basic structure of what leads to a fracture. All it does is change the chance that you will get there, if you have made some error in your seismic analysis.

MR. BLEY: Well we haven't done a seismic analysis but yes, it could change the frequency of the major contributors --

UNIDENTIFIED SPEAKER: Having been in charge of one of the plants, I can tell you the seismic analysis was done twice. Once, wrong.

MR. BLEY: So anyway, I will go back and look some more at those two.

MR. shack: No, I think you raise a good point but if you take the rate of change, by the time you get to 65 it is a large number of changes.

MR. BLEY: Yes. There is nothing there to say we have seen all we have got to see.

UNIDENTIFIED SPEAKER: On the other hand, the generalization, you weren't looking for a great deal of -- all you were looking for was the major things, I thing.

MR. KIRK: A factor of two -- you know, we have used the 95th percentile for the results, which is, you know, again, some sort of conservatism that accounts for some things.

MR. BLEY: And you tried to cover uncertainty pretty well. I mean, this project did a better job on that than most.

UNIDENTIFIED SPEAKER: They promised at the outset that they were going to a definitive, absolutely rigorous analysis and they backed way off on that.

MR. KIRK: That was a claim of our predecessors who then left for bigger and better.

MR. SHACK: But Dennis is still right. It is better than we have seen on anything else.

MR. BLEY: It is much better than we have ever seen. Yes, I will grant you that. But we were promised more. We were promised nirvana and we didn't believe it at the time.

MR. KIRK: I think maybe on thing too, just to comment on Dennis' question of why are such a small population of things matter. I think in a lot of cases when we enter into these analyses, depending upon how rigorously we characterize things, we essentially set up the end result.

I mean, if we had taken the approach of taking very conservative approximations of material properties and overestimating flaw sizes and increasing fluences and so on. And overestimating -- well, I will stay out of the PRA side. I will just talk about things I think I know about. Overestimating the thermal hydraulic severity and so on, what you get is then all of the transients would be producing more load, if you will, and the vessel overall would have less resistance.

So instead of having just two dominant contributors and one minor contributor, you would have a lot more because more things would count. So, I think in some sense we, by the way we did the project at the beginning and trying to make as accurate and realistic a model as we could and I use the model in a general sense, we made generalization easier because a lot of things that might have based on more conservative models been thought to be important, just weren't.

And so to me it kind of comes down from a methodology viewpoint it is you pay me now or you pay me later. You spend a lot of time up front and do as accurate a job you can at estimating severity and resistance and you find out that only very few classes of things, only the most severe things are important and those might, as we found out here, be fairly uniform over the fleet or you spend less time at the beginning, maybe talk to bodies such as this at the two-year point, instead of at the ten year point. But then I don't think we would have a general rule. Just an observation.

MR. DINSMORE: I also would like to add that Indian Point came in for an extension of their reactor vessel from ten to twenty years and they had a problem with a bounding calculation and we asked them to go back and evaluate their plant against the generalization study. And they did and they came in not surprisingly and they went through the main points and they said well this is similar, this is similar. So there is at least one more plant that did it.

And if they run into a problem with the calculations or as Matt was saying earlier, they could get into a point where they need to do something. And if that something is to recalculate the TWCF, we would ask them to do the whole thing. I mean, if there is a question about whether they are meeting that limit or not, the anticipation, at least as I understand it would be they would have to go and really do a comprehensive study to continue.

So, in that respect, there is some way to recover later on. Although, they wouldn't get there unless they had problems with their flaws. But if they have their problems with their flaws, then they are going to have to do these analysis.

MR. MITCHELL: Yes, we would certainly have the opportunity to review the information and deem whether or not there was additional information that we would want to pursue on a plant-specific basis when that case arises.

I guess I just would reemphasize that although it is not really a compelling argument relative to the rule itself but I think the expectation is in fact that we are going to have the portion of the fleet that wants to use this rule is going to be very far from the screening limits and have, if expectations hold, flaw distributions that are far from the criteria that are specified in the rule.

And so although the rule permits, would permit you to go right up effectively to those limits, in reality space, it does not appear that there is any vessel that is going to be close to pushing both of those boundaries to their limit and be in fact anywhere close to one times ten to the minus six at any conceivable operating lifetime when you pile those together in that fashion.

I know that doesn't directly answer the question about the medium break LOCAs seismic sensitivity but I guess it gives me some confidence that there is probably also going to be enough slop in how far the plants are actually away from the limits that I am not sure that that particular additional nuance is going to be the make or break. It is not going to, I don't think, going to keep me up at night thinking that there is actually a plan out there that is greater than one E minus six in any circumstance.

UNIDENTIFIED SPEAKER: I have a question that goes back to the basics and your original study. Three plants you examined in detail. Did you examine in detail the NVU vessel itself to determine if there was a significant flaw that would invalidate a conclusion on fracture toughness?

MR. KIRK: No, not in those plants. The basis of our flaw distribution was primarily from the destructive evaluation of X vessel materials was done by TNNL Press (phonetic).

UNIDENTIFIED SPEAKER: Who requires the licensee to go --

MR. KIRK: That's right. The rule requires the licensee to do that.

UNIDENTIFIED SPEAKER: -- analyze what the flaw structure is to apply the Probabilistic Fracture Mechanics.

MR. KIRK: Yes. Well hopefully he won't have to do that. Hopefully he will be within the bounds of what they have already done.

MR. MITCHELL: Especially when you consider that those flaw distribution studies very liberally included things to be defined as flaws in terms of what was actually observed in the material.

I mean, I think if you compared what came from the flaw distribution development versus actual real crack-like indications in any vessel, there are going to be very few and far between relative to the densities that were used in the actual PTS work.

But I mean, I think it is true that the flaw distribution phase does not lend themselves to things that were specifically crack-like.

MR. KIRK: No.

MR. MITCHELL: They declared things to be indications of relevance.

MR. KIRK: And in fact there was considerable complaint from some of our industry colleagues that we had improperly characterized certain volume metric defects as flaws and that therefore the PTS reevaluation was doomed to failure.

So yes, Matt is right. There were things that we elected to count. We erred on the side of being conservative but not too conservative.

MR. BANERJEE: Were you able to characterize the flaws in this belt line 12?

MR. KIRK: No. The flaws that we characterized came from vessels that never made it to service but not from the plants that are out there operating.

UNIDENTIFIED SPEAKER: Not necessarily PWRs.

MR. BANERJEE: (Inaudible) with a BWR.

MR. KIRK: Right.

MR. BANERJEE: How do you know that this is the flaw?

MR. KIRK: That is why we check.

MR. SHACK: I mean, that is in many ways the largest uncertainty. You know less about that than you know about anything else.

UNIDENTIFIED SPEAKER: If you want to go to Hanford and dig one up, you can.

MR. BANERJEE: I guess other than thermal hydraulics --

MR. CORRADINI: That is the queen of science. That is exact. Right?

MR. BANERJEE: Mike, you are very optimistic.

UNIDENTIFIED SPEAKER: Yes but that is an easy to deal with question. Thermal hydraulics are so simple. So to speak.

MR. BLEY: It really boils down to your properties, the flaws in the vessel proven that the pressure isn't going to make a whole lot of different in PTS which really surprised me. I always thought there would be some optimum condition of pressure and cooling rate and whatever.

UNIDENTIFIED SPEAKER: Well, one of the interesting things is when you stress operator action, you could end up with a TMI event where the operator is at play here in PTS cracking of the vessel and turns off his injection flow and the vessel stayed in tack but the core melted.

MR. MITCHELL: One of the down sides.

CHAIRMAN SHACK: Okay, any further comments? Sanjoy?

MR. BANERJEE: No thanks.

CHAIRMAN SHACK: You are allowed. You are an ACRS member. You can pontificate to your heart's content.

Well, if there are no additional comments or questions -- Matthew?

MR. MITCHELL: I was just going to ask quickly in summary, were there any particular points that the subcommittee would like us to stress at the full committee meeting tomorrow that we could use to better inform our presentation?

UNIDENTIFIED SPEAKER: I don't know if it can be done.

MR. MITCHELL: Okay, we are only accepting things that can be done.

UNIDENTIFIED SPEAKER: See this curve?

MR. KIRK: Yes.

UNIDENTIFIED SPEAKER: If you could somehow turn that into a circus. You know, this looks really important here but it really isn't because that's really down to ten to the minus twelve and this is ten to the minus six. I would just, I would start it --

MR. KIRK: You want the third dimension in terms of probability.

UNIDENTIFIED SPEAKER: This really tells you, it puts the whole story together of where this is important, there is not much cracking.

MR. KIRK: Yes.

UNIDENTIFIED SPEAKER: That is about it. That is a nice to do.

MR. BLEY: I think you need to work on your opening comments on the overall strategy and say look, there are three crucial steps I am going to go through here and what those really are. I think that needs to be a lot crisper, a lot clearer because many of the committee members have not been following, haven't been around for most of the presentations on this subject. And now they are all thoroughly brainwashed with Indian Point.

CHAIRMAN SHACK: Well now I think, don't say anything about the public comments. I don't think we need to address that at all. I do think we need to highlight that the main features of the rule, you know, the fact that we are asking them to essentially do a vessel-specific embrittlement and a vessel-specific characterization. But I do that at a fairly high level.

MR. BLEY: Here is my strategy. You know, I am going to create a rule. I am going to ask you to do these vessel-specific. I have done these things for three plants. Now I am going to try to see if I can generalize it at all by looking at another five and lay that strategy out fairly clearly. I mean, this is the first ten minutes.

MR. MITCHELL: Yes, what we had planned for was to spend the very beginning of the presentation talking about the technical basis and as part of that, the generalization aspects of it and then move into a discussion of, okay, and now here is the rule. And here is how we have got the rule framed out and essentially repeat what I said today but only at an even higher level and only pick out the very most salient parts to talk about the --

MR. BLEY: Just begin with a little strategic business and what all they are going to hear and what points that they should talk home and what points they can blow off.

MR. MITCHELL: Okay, we will see if we can achieve that tomorrow.

MR. BANERJEE: And drop the P out.

UNIDENTIFIED SPEAKER: And you can say anything bad about thermal hydraulics you want. That is okay.

CHAIRMAN SHACK: At that point, we are adjourned.

(Whereupon, the foregoing meeting was adjourned.)

(End Tape 2, Side 2.)

Alternate Fracture Toughness Requirements for Protection against Pressurized Thermal Shock (PTS) Events Rule
(10 CFR 50.61a)

NUCLEAR REGULATORY COMMISSION

10 CFR Part 50

RIN 3150–AI01

[NRC–2007–0008]

Alternate Fracture Toughness Requirements for Protection Against Pressurized Thermal Shock Events

AGENCY: Nuclear Regulatory Commission.

ACRS Subcommittee Meeting
March 4, 2009

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

Rulemaking Working Group

Alternate PTS Rule

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

• Barry Elliot	NRR/DCI
• Matthew Mitchell	NRR/DCI
• Stephen Dinsmore	NRR/DRA
• Lambros Lois	NRR/DSS
• Veronica Rodriguez	NRR/DPR
• Mark EricksonKirk	RES/DE
• Robert Hardies	RES/DE
• Nihar Ray	NRO/DE
• Geary Mizuno	OGC

Agenda

Alternate PTS Rule

- Three Main Topics:
  - Final Rule Language (10 CFR 50.61a)
  - Public Comments and NRC Responses
  - Generalization Study

Alternate PTS Rule

Overview

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

- 10 CFR 50.61a structured similarly to 10 CFR 50.61
- Similarity emphasized to facilitate implementation by both the industry and the NRC staff
- Differences between the two rules reflect critical features

Alternate PTS Rule

10 CFR 50.61a(a) - Definitions

U.S.NRC
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- Where applicable, definitions used in 10 CFR 50.61 were maintained
- Definition of “ASME Code” broadened to included Section XI in support of inservice inspection (ISI) related topics addressed in 10 CFR 50.61a
- Terms specific to 10 CFR 50.61a and terms not found in 10 CFR 50.61 were added and defined

Alternate PTS Rule

10 CFR 50.61a(b) - Applicability

U.S.NRC
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- Use of 10 CFR 50.61a limited to existing fleet of pressurized water reactors (PWRs) and technologically similar units (e.g., Watts Bar 2, Zion, etc.)

- Only the existing generation of PWR units has been explicitly demonstrated to conform to the technical basis for the rule

- If necessary, the licensees of future units could request exemptions from the restrictions of 10 CFR 50.61a(b) under the provisions of 10 CFR 50.12

Alternate PTS Rule

10 CFR 50.61a(c) - Request for Approval

U.S.NRC
United States Nuclear Regulatory Commission
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- NRC retains review and approval authority over any licensee's use of the rule
- Warranted due to both the complexity of the rule and the significance of the issue
- Timing consistent with requirements of 10 CFR 50.61

Alternate PTS Rule

10 CFR 50.61a(c) - Request for Approval

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

- Information to be submitted in request:
  - Material property ($RT_{MAX\text{-}X}$) values compared to the rule's screening criteria, including consideration of reactor pressure vessel (RPV) surveillance data
  - An evaluation of RPV ISI data to demonstrate consistency with the technical basis of the rule

Alternate PTS Rule

10 CFR 50.61a(d) - Subsequent Requirements

- After initial approval to implement the rule, licensee must submit for NRC approval:
  - Updated RT_{MAX-X} values to ensure continued compliance with the screening criteria
  - Updated evaluations of RPV ISI data gathered as part of the facility's ASME Code ISI program

Alternate PTS Rule

10 CFR 50.61a(d) - Subsequent Requirements

U.S.NRC
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- Should a licensee subsequently determine that the RPV exceeds the screening criteria of the rule, options similar to those in 10 CFR 50.61 apply:
  - Flux reduction
  - Plant modifications
  - Advanced analyses
  - Thermal annealing

Alternate PTS Rule

10 CFR 50.61a(e) -Examination and Flaw Assessment

- Section (e) applies to both initial and subsequent evaluations
  - Based on the use of ASME Code qualified inspection techniques
  - Permits results to be adjusted in consideration of nondestructive examination (NDE) uncertainties
  - Requires comparison to acceptance criteria in the rule (i.e., tables) and ASME Code

Alternate PTS Rule

10 CFR 50.61a(e) -Examination and Flaw Assessment

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- Failure to meet the flaw distribution inspection requirements leads to:
  - Analysis of the RPV to demonstrate acceptable through-wall cracking frequency (TWCF)
  - Nature of the analysis may vary depending on case-specific factors

Alternate PTS Rule

10 CFR 50.61a(f) – Calculation of RT_{MAX-X} Values

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- Calculation of RT_{MAX-X} values is similar to the calculation of RT_{PTS} values in 10 CFR 50.61
- Differences:
  - RT_{MAX-X} does not include a "margin" term
  - For welds, determination of RT_{MAX-X} must also consider associated plate/forging properties
  - Determination of RT_{MAX-X} values requires the use of updated embrittlement models and RPV surveillance data evaluations

Alternate PTS Rule

10 CFR 50.61a(f) – Calculation of RT_{MAX-X} Values

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- Updated embrittlement models:
  - Based on expanded database of surveillance capsule results when compared to 10 CFR 50.61 models
  - Combine statistical analysis of data and mechanistic understanding of radiation embrittlement
  - Incorporate a wider range of material (P, Mn) and environmental (ϕ , T_c) variables

Alternate PTS Rule

10 CFR 50.61a(f) – Calculation of RT_{MAX-X} Values

U.S.NRC
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- Updated RPV surveillance data evaluations:
  - Used to verify the applicability of the 10 CFR 50.61a embrittlement models
  - Tests are more statistically rigorous
  - Targeted to find surveillance data sets which may indicate that embrittlement models are behaving non-conservatively

Alternate PTS Rule

The final 10 CFR 50.61a provides an effective and useful approach for addressing the PTS issue by maintaining adequate protection, as demonstrated by the state-of-the-art technical basis which supports the rule, without imposing unnecessary regulatory burden on licensees.

Public Comments

Overview

- Proposed Rule issued on October 3, 2007
  - Comment period closed December 17, 2007
  - 5 comment letters
    - Pressurized Water Reactor Owners Group
    - Electric Power Research Institute
    - Nuclear Energy Institute
    - Duke Energy
    - Strategic Teaming and Resource Sharing
  - Total of 54 comments

Public Comments

Overview

- Supplemental Proposed Rule issued on August 11, 2008
  - Comment period closed September 10, 2008
  - 3 comment letters
    - Pressurized Water Reactor Owners Group
    - Electric Power Research Institute
    - FirstEnergy Nuclear Operating Company
  - Total of 5 comments

Public Comments

NRC Approach

- Comments evaluated, assigned an identifier number and binned into categories:
  - Proposed Rule:
    - Embrittlement trend curves and fluence maps
    - Surveillance data
    - Flaw limits and flaw density determinations
    - Miscellaneous
  - Supplemental Proposed Rule:
    - Adjustments of ISI volumetric examination
    - Surveillance data

Public Comments

Updated Embrittlement Trend Curves

- Principle Comment
  - Remove embrittlement model from the rule and only require the use of an NRC approved methodology

- NRC Response - Disagreed with Comment
  - Model included to ensure consistency with technical basis and to provide regulatory certainty

Public Comments

Surveillance Data Evaluation

- Principle Comment
  - Eliminate the requirement to assess surveillance data, because variability is included in model derivation
- NRC Response – Disagreed with Comment
  - Surveillance data evaluations retained, and enhanced, to ensure that embrittlement models are not behaving non-conservatively

Public Comments

Flaw Limits and Density Determinations

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- No Single Principle Comment
  - Commenters provided numerous, specific comments regarding improvements and/or clarifications to Section (e)

- NRC Response – Variable
  - Changes made to final rule and the statements of consideration to provide clarification or improvement where applicable

Public Comments

Miscellaneous

- No Single Principle Comment
  - Comment from Duke regarding evaluation of steam generator overfeed events of interest

- NRC Response
  - Reevaluated the event sequence and demonstrated that the rule, and its technical basis, were not adversely impacted

Public Comments

Adjustments to ISI Data

- Principle Comment
  - Commenters agreed with NRC staff proposal to incorporate potential consideration of NDE uncertainty in meeting Section (e) requirements
- NRC Response – Agreed with Comment
  - Modified final rule as proposed in supplemental proposed rulemaking

Public Comments
Surveillance Data Evaluation

- Principle Comment
  - Eliminate the proposed surveillance data slope check
- NRC Response – Disagreed with Comment
  - Slope check retained in final rule to ensure that embrittlement model is making appropriate prediction at high neutron fluence levels

Generalization Study

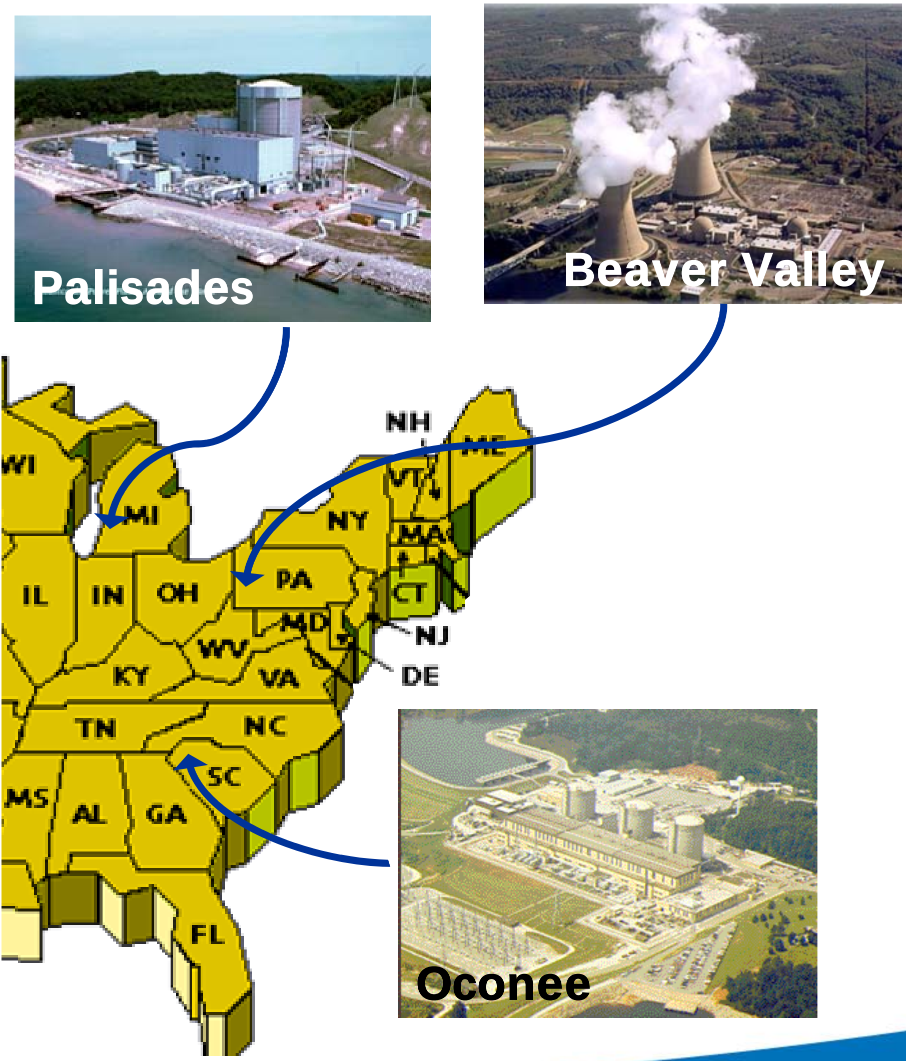
Outline

- Overview of technical basis results to provide context for generalization study
  - Dominant transients
  - Dominant material features

- Generalization study
  - Probabilistic risk assessment (PRA) similarities
  - Thermal hydraulics (TH) similarities

Technical Basis

Plants Studied



Detailed analysis of 3 PWRs

- All PWR manufacturers
  - 1 Westinghouse (W)
  - 1 Combustion Engineering (CE)
  - 1 Babcock & Wilcox (B&W)
- 1 plant from original (1980s) PTS study
- 2 plants very close to the current PTS screening criteria

Technical Basis

Transient Classes Modeled

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Primary System Faults

- Pipe breaks
  - Break diameters from 2 to > 16 inches
- Stuck open valves that later re-close
- Feed and bleed (F&B)

Secondary System Faults

- Main steam line break (MSLB)
- Stuck open valves
- Steam generator (SG) tube rupture
- Pure overfeed

Important Transient Classes

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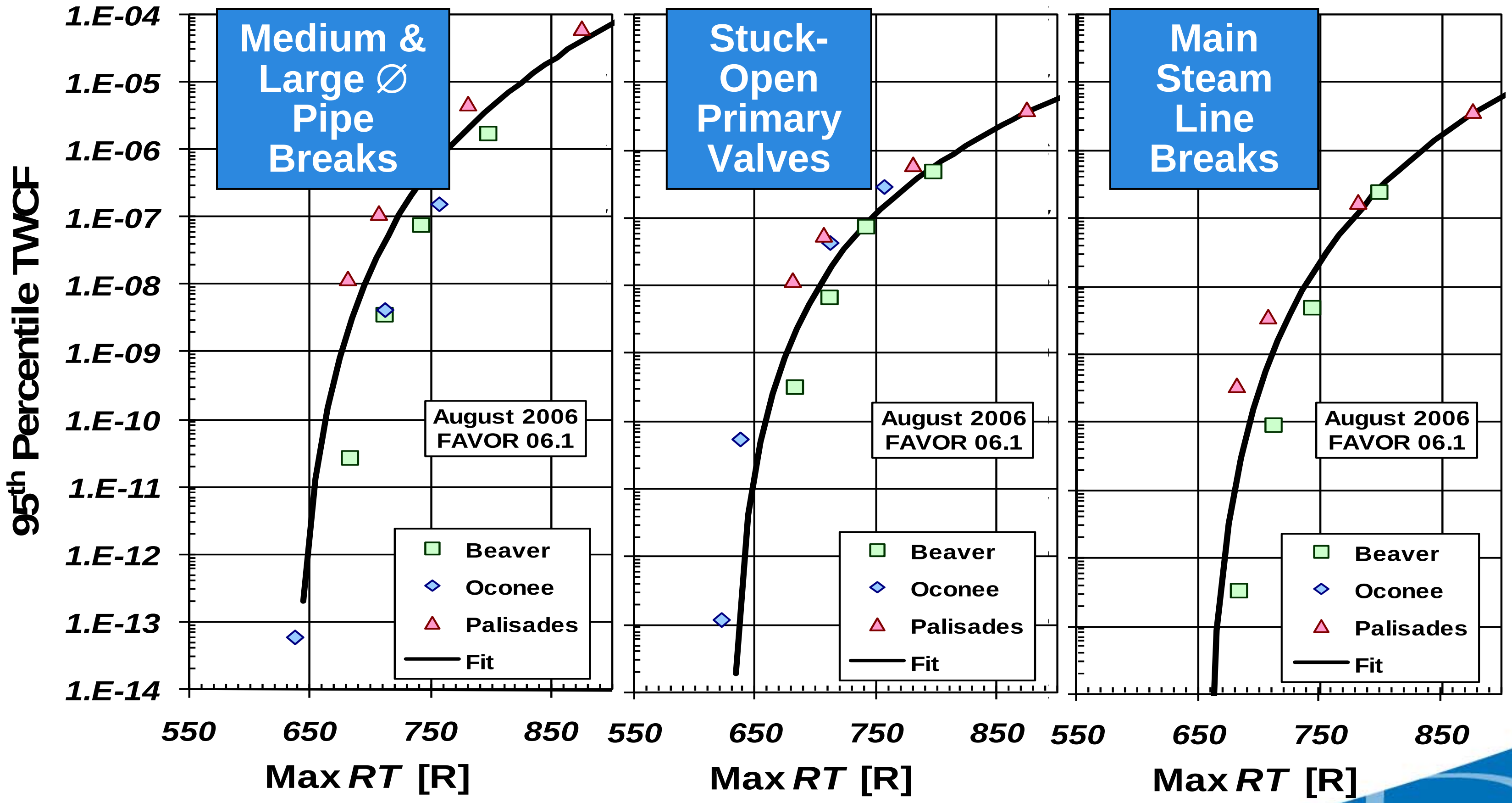
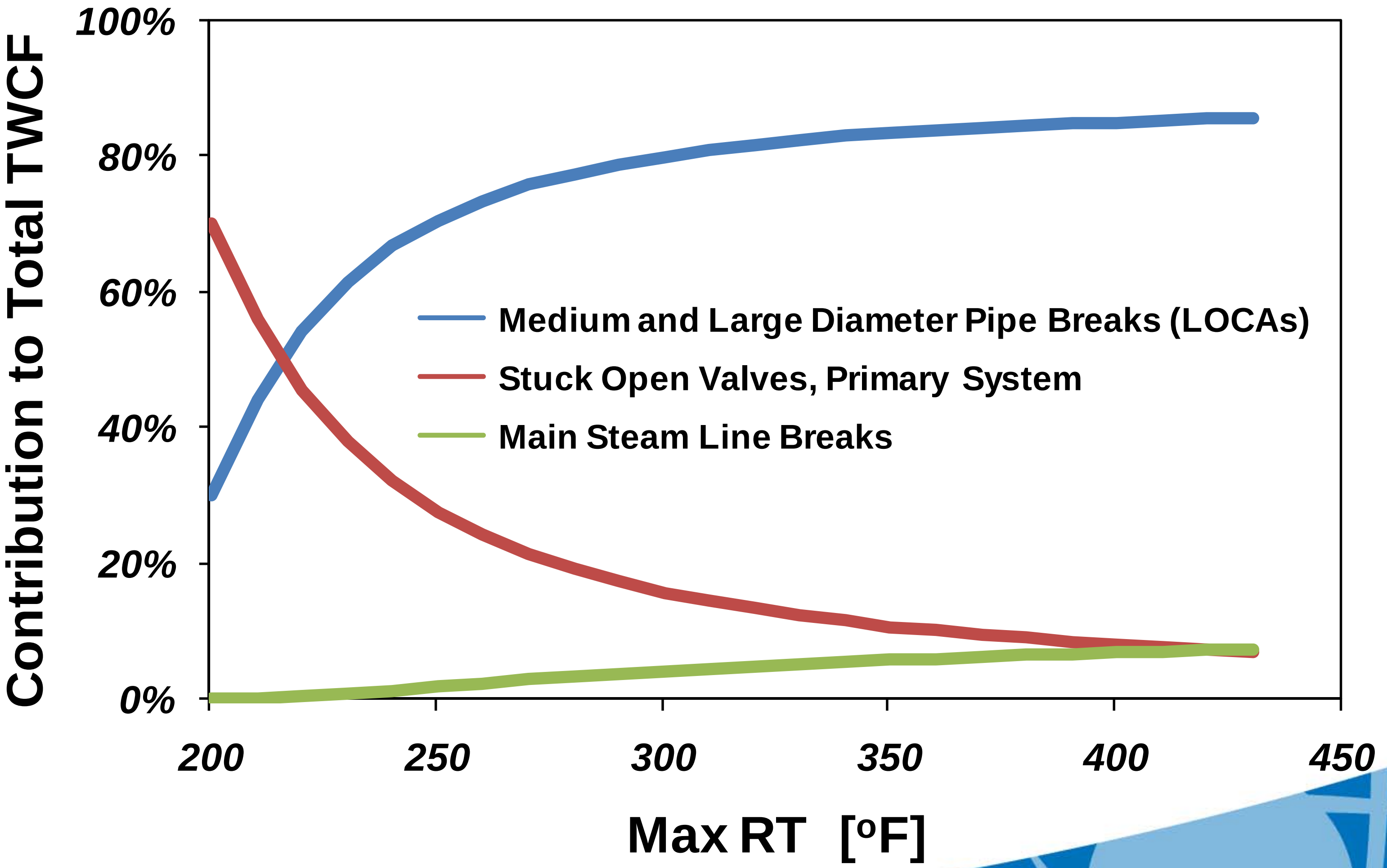


Important Transient Classes



Important Transient Classes

Summary of Findings

- Very severe secondary faults (i.e., MSLB) make a minor contribution
  - Primary side temperature cannot fall below 212^{o}F, so material still tough even at high embrittlement
- Primary side faults dominate risk
  - Primary side temperatures can fall considerably below 212^{o}F
- Other transient classes produce no significant risk
  - Challenge is low even if transient occurs

Summary of Findings

Stuck-Open Primary Valves

- Dominate risk at low embrittlement
- Failures driven by factors that are similar across the PWR fleet
  - Low reactor coolant temperatures at time of re-pressurization
  - Re-pressurization to the safety valve setpoint
- Rapid operator action (i.e., high pressure injection (HPI) throttling) can influence this scenario; however, even if credit for operation action was removed, the screening criteria will not change
- These factors suggest generalization is possible

Summary of Findings

Medium and Large LOCAs

- Dominate risk at higher embrittlement
- Failures driven by factors that are similar across fleet
  - Rate of cooling of the primary system water exceeds that achievable by the RPV wall, so the transient severity depends on:
    - Steel thermal conductivity
    - Vessel diameter and thickness

    Not by the TH characteristics of the transient (i.e., is vessel-limited)
  - Emergency core cooling systems operate automatically. Therefore operator actions do not play a role in these transients
- These factors suggest generalization is possible

Summary of Findings

Main Steam Line Breaks

- Slight effect at very high embrittlement
- Failures driven by factors that are similar across the PWR fleet
  - Rate of cooling of the primary system water exceeds that achievable by the RPV wall
  - Temperature in primary cannot fall below 212ºF because of secondary side interaction.
- Failures, if they occur, happen before operator action is probable
- These factors suggest generalization is possible

Summary of Findings

All Together

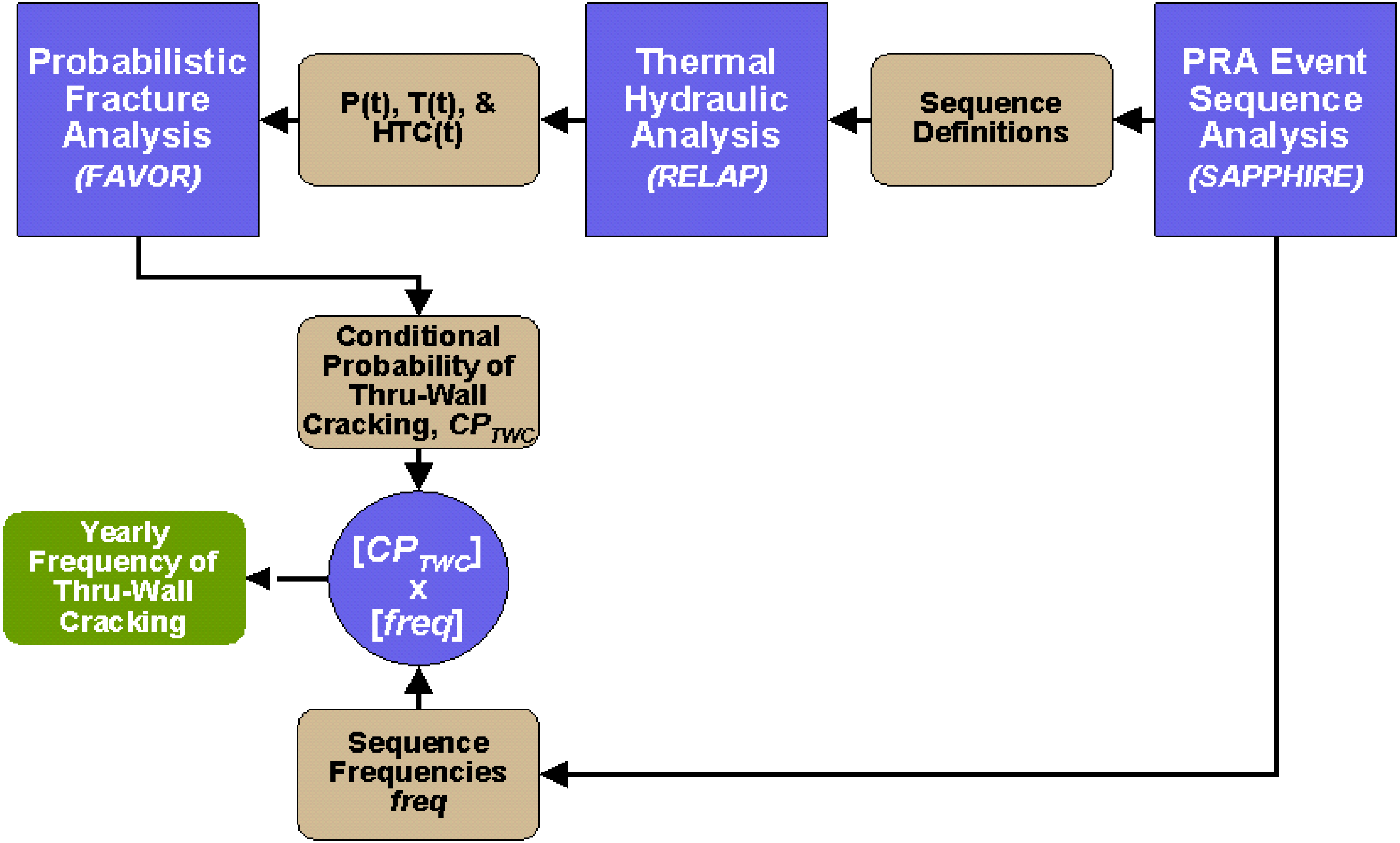
- Only the most severe transients contribute to risk
- The characteristics of these transients are similar across the PWR fleet
- These factors suggest generalization is possible

Generalization Study
Overview

- Investigated whether the RT screening limits developed from the PTS technical basis work apply to all PWRs in the U.S.
  - PRA
  - TH
- Concluded that PRA and TH characteristics do not have to be investigated for each plant

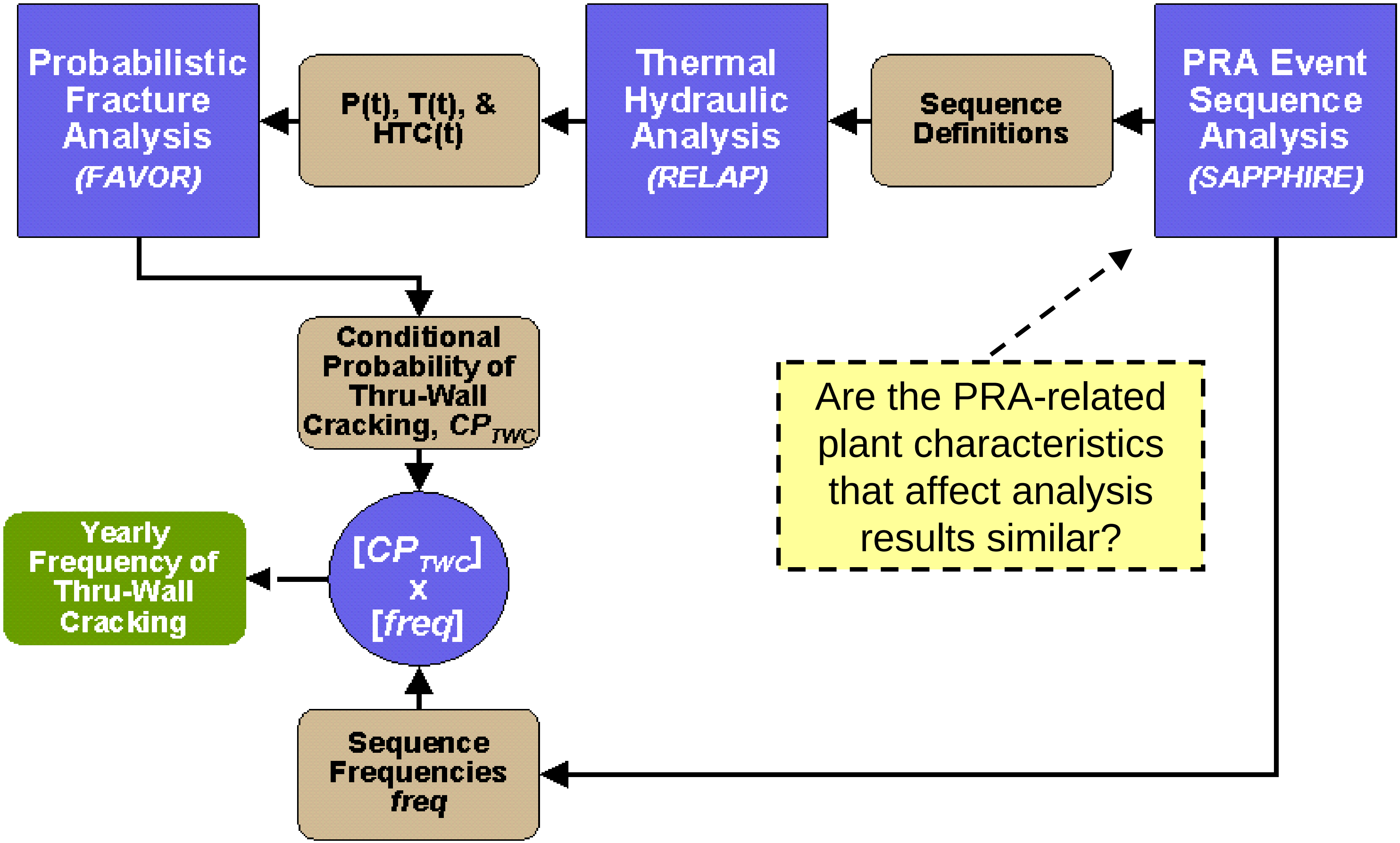
Generalization Study

Overview - Is Generalization Possible?



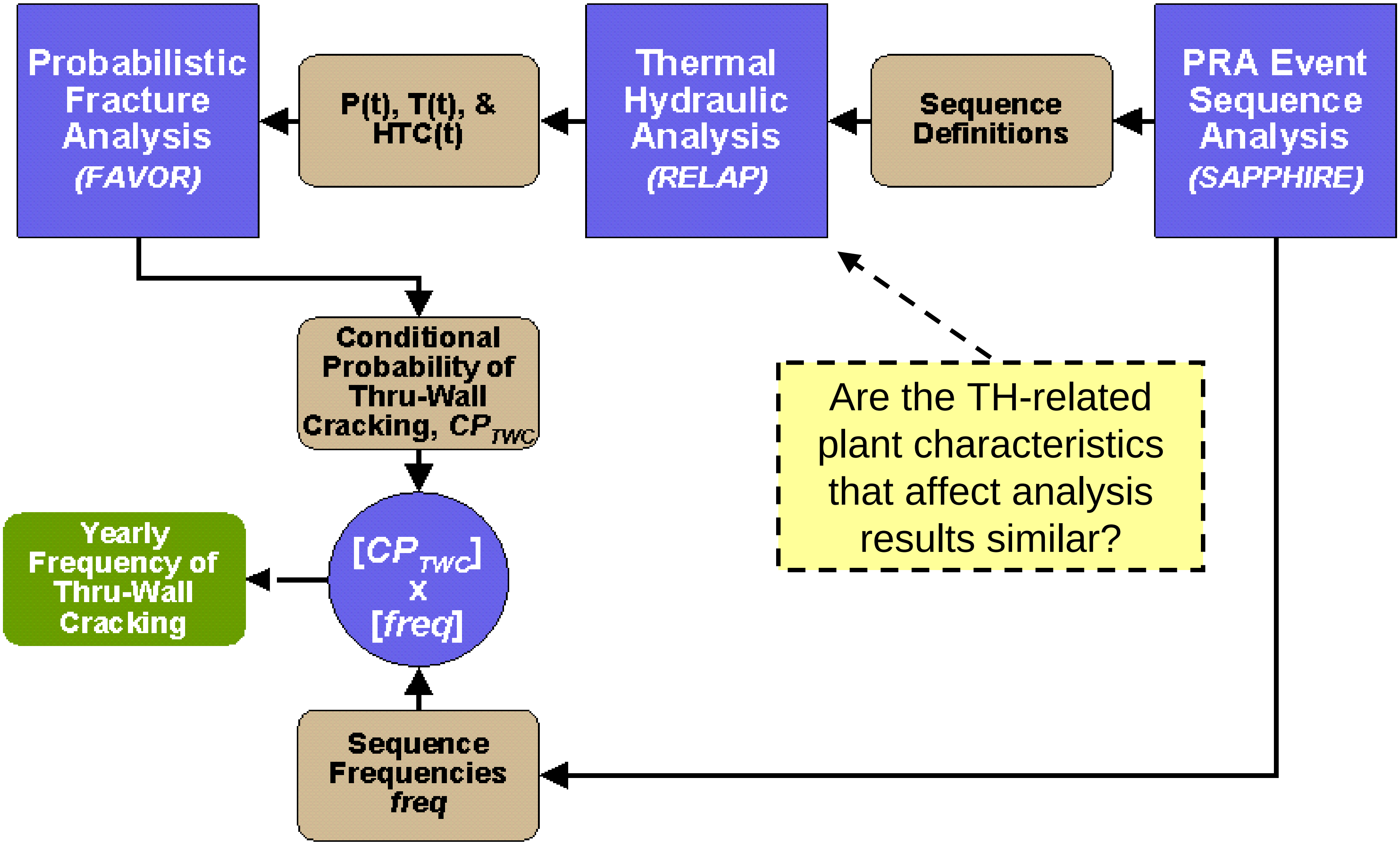
Generalization Study

Probabilistic Risk Assessment



Generalization Study

Thermal Hydraulic



Generalization Study

Methodology

- Original detailed study - 3 plants
  - Beaver Valley (W – 3 Loop)
  - Oconee (B&W)
  - Palisades (CE)
- Chose 5 more high embrittlement plants
  - Salem, Unit 1 (W – 4 Loop)
  - Three Mile Island, Unit 1 (B&W)
  - Fort Calhoun (CE)
  - Diablo Canyon, Unit 1 (W – 4 Loop)
  - Sequoyah, Unit 1 (W – 4 Loop)
- Questionnaire used to collect information on the 5 additional plants

PRA Generalization

Frequency of PTS Challenge

- Questions
  - Do the important sequences in the 5 generalization plants occur with similar, or lower, frequency as in the 3 study plants?
  - Are there any unimportant sequences that could become important?

TH Generalization

Severity of PTS Challenge

- Questions
  - Do the important transient classes in the 3 study plants have the same, or higher, severity as in the 5 generalization plants?
  - Are there any unimportant transient classes in the 3 study plants that are expected to have a much higher severity in the 5 generalization plants?

Generalization Study

Results

- Generalization of Plant-Specific Pressurized Thermal Shock (PTS) Risk Results to Additional Plants, dated December 14, 2004 (ADAMS Accession No. ML042880842)
(See Section 9.3 in main report)

- Compares key PRA and TH characteristics

Generalization Study

- 5 general PRA event scenarios identified and evaluated
  - Secondary breaches
  - Secondary overfeed
  - Medium and large loss of coolant accident (LOCA) related
  - Power operated relief valve (PORV) and primary safety relief valve (SRV) related
  - F&B related

Generalization Study

Probabilistic Risk Assessment

- Secondary Breaches (e.g., feed line break)
- Not an important scenario at low or high embrittlement
- Investigated:
  - Ability of operators to identify the faulted SG
  - Procedures to isolate feed to the faulted SG
  - Procedures for proper steaming of good SG
- Concluded that lack of automatic AFW isolation at some units might increase frequency, but that operators have multiple opportunities to identify and isolate the faulted SG. Therefore, these scenarios are not expected to become important at any operating PWR.

Generalization Study

Probabilistic Risk Assessment

- Secondary overfeed
  - Not an important scenario at low or high embrittlement
  - Issues identified for comparison are only the TH issues associated with overcooling of primary by secondary

- Medium and Large LOCA related
  - Not an important scenario at low embrittlement but becomes important at high embrittlement
  - Issues identified for comparison are only the TH issues associated with medium and large LOCAS

Generalization Study

Probabilistic Risk Assessment

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- PORV and primary SRV related
  - An important scenario at low embrittlement that becomes unimportant at higher embrittlement
  - Investigated:
    - Number and sizes of PORVs and SRVs
    - Capability to identify stuck open valves
    - Procedures for coping with stuck open valves
    - Procedures for coping with sudden valve re-closure
  - Concluded that differences in capability to identify stuck open valves might increase the scenario frequency, but not enough to make the scenario important at high embrittlement. Therefore, these scenarios are not expected to become important at any operating PWR.

Generalization Study

Probabilistic Risk Assessment

- F&B related
  - An unimportant contributor
  - Investigated:
    - Capacity of secondary feed whose failure would lead to F&B
    - Procedures directing implementation of F&B
    - Number of PORVs or SRVs for bleed
    - HPI systems for feed
  - Concluded that likelihood of losing secondary feed might be different between plants but not enough to make scenario important at any operating PWR.

Generalization Study

Thermal Hydraulic

- 4 general transient classes were identified and evaluated:
  - Large LOCAs (>8.0 inches)
  - Medium LOCAs (2.0 - 5.7 inches)
  - Stuck open primary valves that reclose (re-pressurization transients)
  - Overcooling of primary by secondary

Generalization Study

Thermal Hydraulic

- Large LOCAs (> 8.0 inches)
  - Generally important contributor that becomes controlling at high embrittlement
  - Defined as not critical flow limited
  - Investigated:
    - Reactor thermal power levels
    - Injection run-out flow
    - Water volume and temperature in injection storage tanks
- The behavior of this transient class is vessel-limited and any differences in the temperature in the downcomer would not be significant. Therefore, this important transient class is not expected to become more severe at any operating PWR.

Generalization Study

Thermal Hydraulic

- Medium LOCAs (2.0 - 5.7 inches)
  - Generally important contributor that becomes controlling at high embrittlement
  - Defined as critical flow limited
  - Investigated
    - Reactor thermal power levels
    - Timing of safety injection tank discharge and low pressure injection including affect of break size limiting injection flow
    - Water volume and temperature in injection tanks
  - The behavior of this transient is generally vessel-limited. In addition, the capacity of high and low pressure system flow is generally scaled to core power so depressurization and cooldown rates at all operating PWRs should be similar to the study plants.

Generalization Study

Thermal Hydraulic

U.S.NRC
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- Stuck open primary valves that reclose (re-pressurization transients)
  - An important scenario at low embrittlement that becomes unimportant at high embrittlement
  - Investigated:
    - Initial characteristics at low end of medium LOCAs break size followed by re-pressurization
    - Size, number, and configuration of PORVs and SRVs
    - Operator control of reactor pressure and subcooling
    - HPI is limited by PORV/SRV capacity and is not operating at runout conditions
  - There might be differences in rate of cooldown and re-pressurization between plants (e.g., Fort Calhoun with its larger relief capacity) but not enough to make the transient class important at high embrittlement

Generalization Study

Thermal Hydraulic

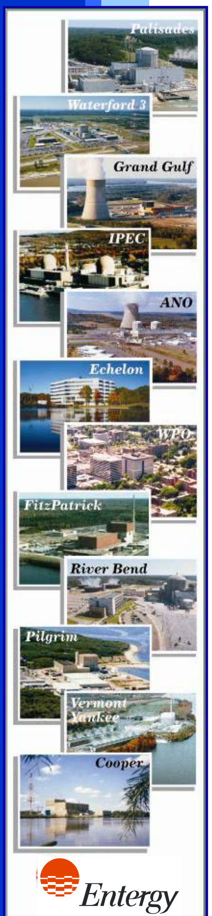
- Overcooling of primary by secondary
  - Not an important contributor that becomes a minor contributor at high embrittlement
  - Investigated:
    - Size and location of secondary break
    - Flow restrictions
    - Operator actions to isolate and use remaining systems structures and components to retain control of secondary heat removal
  - Scenario is bounded by MSLB. All PWRs are expected to cool down at or about the same rate as the study plants. Therefore, the results of the study plant analyses are expected to represent the behavior of the fleet as whole.

Generalization Study

Summary

- The PTS technical basis appropriately modeled the challenge type, frequency, and severity of PTS events in the study plants
- The generalization study found that the study plants well represent the operating PWR fleet
- **This information demonstrates that plant-specific PRA and TH evaluations are not needed to implement 10 CFR 50.61a**

SBO Recovery



IP2 Offsite Power Scoping Diagram

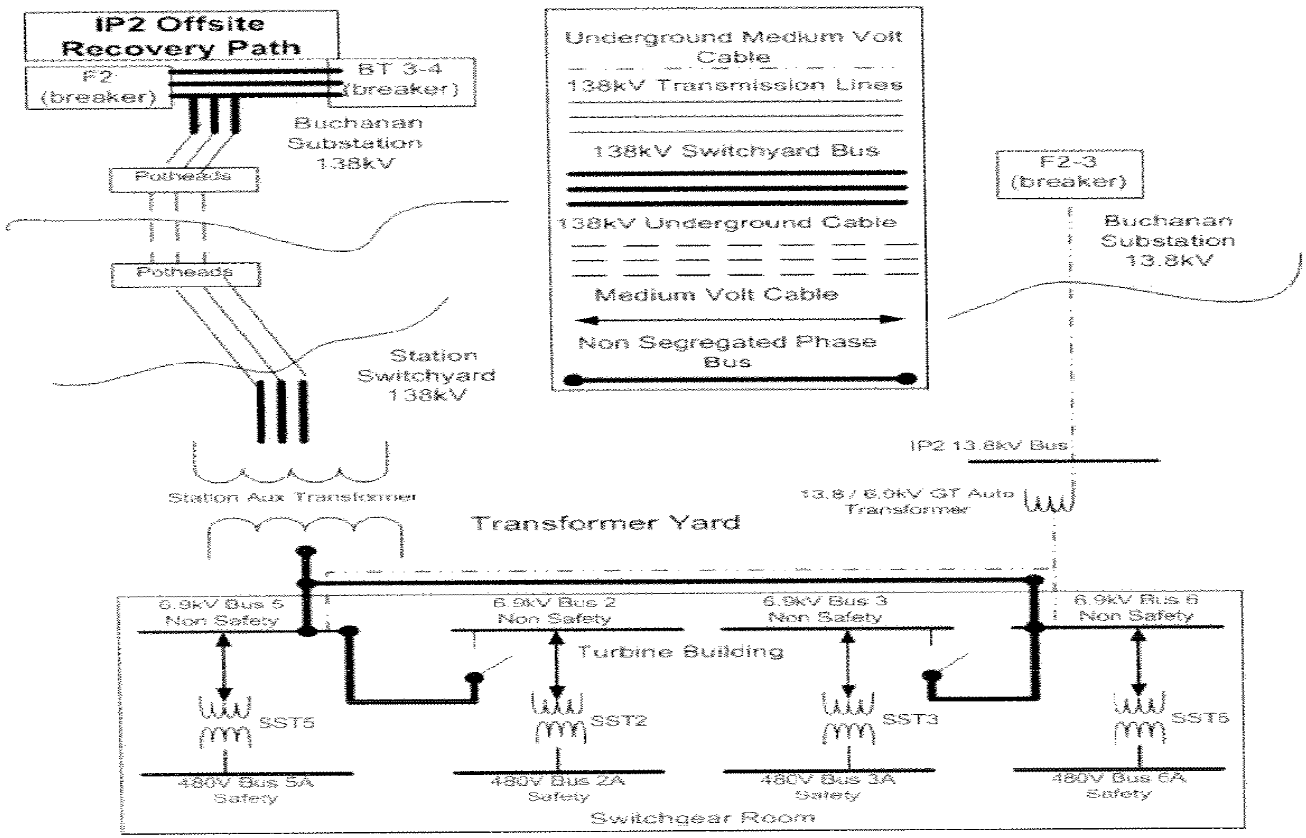
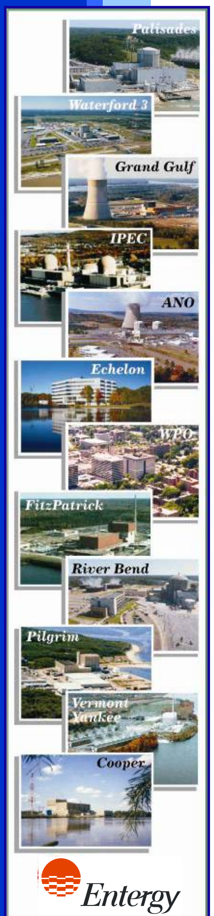


Figure 2.5-2

SBO Scoping



Buchanan Substation