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Meeting Title: Meeting with Boiling Water Reactor Vessel and Internals Project (BWRVIP) and NRC Staff

Meeting Date: 5/12/97

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Title: MEETING WITH BOILING WATER REACTOR VESSEL AND INTERNALS PROJECT AND NRC STAFF - PUBLIC MEETING

Location: Rockville, Maryland

Date: Monday, May 12, 1997

Pages: 1 - 76

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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MEETING WITH BOILING WATER REACTOR VESSEL

AND INTERNALS PROJECT AND NRC STAFF

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PUBLIC MEETING

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Nuclear Regulatory Commission
Commission Hearing Room
11555 Rockville Pike
Rockville, Maryland

Monday, May 12, 1997

The Commission met in open session, pursuant to notice, at 3:05 p.m., the Honorable SHIRLEY A. JACKSON, Chairman of the Commission, presiding.

COMMISSIONERS PRESENT:

SHIRLEY A. JACKSON, Chairman of the Commission
KENNETH C. ROGERS, Member of the Commission
GRETA J. DICUS, Member of the Commission
NILS J. DIAZ, Member of the Commission
EDGAR McGAFFIGAN, JR., Member of the Commission

STAFF AND PRESENTERS SEATED AT THE COMMISSION TABLE:

JOHN C. HOYLE, Secretary

STEVEN BURNS, Deputy General Counsel

HUGH THOMPSON, Deputy Executive Director for Regulatory Programs

THOMAS MARTIN, Acting Associate Director for Technical Review, NRR

MICHAEL MAYFIELD, Chief, Electrical, Materials & Mechanical Engineering Branch, RES

JACK STROSNIDER, Chief, Materials and Chemical Engineering Branch, NRR

SAMUEL COLLINS, Director, NRR

CARL TERRY, VP, Niagara-Mohawk, Chairman, BWRVIP Executive Committee

ROBIN DYLE, Project Engineer, Southern Nuclear, Chairman, BWRVIP Assessment Committee

PETE RICCARDELLA, Structural Integrity Associates

PROCEEDINGS

[3:05 p.m.]

CHAIRMAN JACKSON: Good afternoon, ladies and gentlemen. The purpose of today's meeting between the Commission, representatives of the Boiling Water Reactor Vessel and Internals Project and the NRC Staff is to discuss potential policy issues associated with the NRC staff technical position regarding alternatives for augmented inspection of the reactor vessel.

The NRC staff and representatives of the BWR Vessel and Internals Project have interacted over the past 18 months with regard to a proposed alternative to augmented inspection of the reactor pressure vessel.

In a recent Commission paper, SECY 97-088, the NRC staff stated that no alternative to the expedited reactor pressure vessel inspection requirements would be authorized for boiling water reactor licensees until they have completed at least one examination of essentially 100 percent of their reactor pressure vessel welds and have shown that the examination performed provides an acceptable level of quality and safety.

In its letter dated April 18th, 1997, the BWR Vessel and Internals Project stated that an alternative to the current augmented inspection requirements for all domestic BWRs is warranted. The Boiling Water Reactor

Vessel and Internals Project stated that based on a comprehensive study of the reactor pressure vessel design, manufacturing process, in-service inspections to date, operating experience, and extensive probabilistic analyses, only longitudinal shell welds need to be inspected.

Many of these potential policy issues are linked to the staff's determination concerning whether the BWR Vessel and Internals Project's proposed alternative provides an acceptable level of safety.

The Commission looks forward to the discussion with both representatives from the project and the NRC staff. I must say the Commission is interested in understanding what, if any, technical issues relate to policy issues that need to be resolved, and understanding to what extent risk has been considered in the proposed alternative and in the staff's proposed position, and the implications of the staff's position on the industry's time line for performing the augmented inspection.

I understand that copies of the presentations are available at the entrances to the meeting. Unless my fellow Commissioners have any opening comments, Mr. Terry, I guess, you are leading this part of the discussion.

MR. TERRY: Thank you very much. We do appreciate the opportunity to come here.

I'm Carl Terry. I'm vice president of Niagara-

Mohawk and also chairman of the BWRVIP executive committee. There are a number of other people here from the VIP. In fact, we represent a group of 21 utilities and 36 plants. Eight of those utilities and 15 of those plants are represented here today if we do get into more detailed discussions.

The other thing, up here with me is Mr. Robin Dyle from Southern Nuclear and Dr. Pete Riccardella, who are here to support me in presenting. I do believe that our presentation will come to point as far as the specific questions you raised regarding what is our proposed alternative, what are the risks associated with that, and the associated benefits with going ahead with this alternative approach.

CHAIRMAN JACKSON: You also should speak to why you feel the Commission should be involved in resolving what many might consider to be technical issues.

MR. TERRY: Okay. Thank you.

First off, we did provide some slides in advance of the meeting. These slides are slightly different, although technical content will not vary really substantially.

MR. DYLE: They are right there in front of you.

MR. TERRY: And they are there in front of you.

As far as the presentation today, going to the agenda slide, we're going to be -- after I make a few remarks, Mr. Robin Dyle will provide additional detail relating to the inspections that have been performed and the details that we're proposing, along with information relating to those in-service inspections.

Dr. Riccardella will go over the basis for our safety assessment of this issue, and then Robin and I will provide some summary remarks.

Going on to the introduction, what we are proposing is an alternative for the BWR RPV shell weld inspections. We believe that that's based upon a very sound and thorough technical evaluation, as well as included in that are deterministic and risk evaluations of these inspections.

The proposed alternative we believe would result in significant savings. These are both savings in exposure, radiological exposure as well as cost, for the industry with no measurable impact as far as safety.

It is important that this issue be resolved. The reason that we asked to be here and talk to the Commission is because we understand there is a disagreement between us and the staff in terms of the recommendation. We believe it has a sound basis and we felt this would be the most expeditious way of addressing the issue. And w are here today to request the Commission's approval of this proposed alternative.

Just very briefly as far as a little bit of backdrop against the rule, on the history slide, of course, the rule was promulgated in September of 1992, and at that time, there were opportunities to provide comments by the industry. However, following the issuance of that rule, we actually formed the BWR Vessel Internals Project. That came out of a consolidated effort to address some issues related to vessel interrals specifically, but also, as part of that, we did include inspections and evaluations relating to the reactor pressure vessel.

As a result of that group effort, we did initially meet with the NRC to discuss our technical approach in July or August, rather, of 1995. The reason we did that is -- and we're going to get into this in a little more detail -- the primary issue really related to the fact that we couldn't literally meet the rule without some relief, anyway. So we got into looking at alternatives.

Following that initial meeting, we did submit a detailed report with our proposal in September of 1995. Around the middle of last year, we had a meeting with NRC technical staff and senior management, and as far as we know, while there were some requests for additional information that came out, there really are no unresolved technical issues that we know of as far as our submittal.

As far as the specifics on approach, we looked at a number of options, whether it was an exemption to the rule and other things, and we ultimately determined that an authorization for a technical alternative would be an acceptable legal approach to get this job done.

As far as our proposed alternative, in summary, the current RPV shell weld inspection requirements call for essentially 100 percent inspection of all circumferential and longitudinal welds in the shell weld area.

What we are proposing as an alternative is to inspect essentially 100 percent of the axial welds, i.e., the same as the rule with some minor access clarifications, and zero percent of the circumferential welds. We believe this can be handled as a technical alternative under the current regulations.

With that background, unless there are questions, I would like to move now to Mr. Robin Dyle. Robin is from Southern Nuclear. He's technical chair of our Assessment Subcommittee on the VIP and also he's active in a number of ASME Code committees.

Robin.

MR. DYLE: Thank you, Carl.

On the Code and regulatory background slide, just a few key points to make from there. The current Code requirements are to do the 100 percent of the circumferential and longitudinal seam welds, as Carl mentioned; however, we believe that's inappropriate because of a couple of things.

One, the Code treated the BWRs and PWRs as the same when they promulgated the Code changes, and those of us who were there understand that. There's no differences accounted for at a Code level between the experience that BWR would see from fluence, there's no differences in regard to say a PTS event, which is not possible on a BWR but it is on a P.

Secondly, there was no difference in the Code between an axial and circumferential weld, and the stresses are different. So there should be a technical basis for treating those different as far as allowable flaw sizes in, we think, the inspections that would be required.

Secondly, from the regulatory requirement standpoint, when the staff put the rule together in 1992 and invoked the 100 percent requirement from Section 11, they did not consider the differences either in these two points. They treated the Bs and the Ps the same. There was no distinction made between, again, the issues such as PTS and embrittlement related fluence, and there was also no difference in the treatment of how you would evaluate a flaw on the circumferential weld or a longitudinal seam weld.

So those two situations led us to think there were reasons to look at this from a technical standpoint.

Again, as Carl pointed out, most BWRs physically cannot meet the rule, and if you go back and look at the construction history, the construction codes required a lot of things, but one thing that was not in place at that time for most of the BWRs was the Section 11 provisions for inspection, and then as the later plants were being constructed and designed, the rules that were there were not very much in the way of what would be required during in-service inspection. So they were designed and constructed in such a way that there are physical limitations that would prevent us from doing these examinations.

When the rule was put forth, I, representing the owners' group, and some others met with the staff about what was the appropriate way to approach this, because we knew plants couldn't do these examinations, we knew the staff would not want to see 30 or 36 individual relief requests. So we tried to come up with a generic approach, and the next slide really is where we are.

When we went off to do this, we said let's not see how much we ought to reduce the inspections; let's start from ground zero and say what would be the right thing to do for a BWR vessel? What should we inspect? Where should we focus our inspections?

Quite frankly, we were surprised at what we came up with and the recommendation that we have, because we would have thought there would have been more required. But when you go through the technical evaluation again, we think what we're proposing is legitimate.

What we focused on first was safety. We have to operate the plant safely. We have to deal with risk, we have to deal with exposure of personnel.

The second impact or the third impact there would be the cost. There is a cost associated with this, and we looked at that.

Then the last thing, we recognize that the staff has to have defense in depth. That's just a given. They have to know that what we're doing as an industry provides enough assurance that we're operating the plant safely.

So those were the criteria we used and that was the approach that we took going in to try to figure out where we ought to go.

If you would skip two slides over to slide number 9, labelled BWR Fabrication. Just a couple of real quick points I would like to make from a background standpoint. When we went back and looked at this from a fabrication standpoint, here are some of the items that described the vessels. It's shells with rolled plates, you have vertical seam welds and you have circumferential welds.

There are three different welding processes that could be used and there are different cladding steps. One machine clad for most of the shell courses, and then a manual back clad on the field welds.

The bottom line is the seam welds and the cladding all receive a post-weld heat treat, so that's a good thing to have happen.

Also, repair welds, when they were necessary, they were documented and tracked to the same degree that all the vessel welds were done so that you have a high quality repair there, and we know where those repairs are. They're located and we can go find them.

On the next slide, when you get into the fabrication inspections, and I won't go through all the details of those, but there are multiple inspections required. You can see radiography down to penetrant. And then what we've listed there on the presentation are the acceptable flaw sizes that we're concerned with, and construction code.

Typically, if you look at the way these things were put together, the vessel would get an RT and an MT; then you have a PT after cladding to make sure the cladding was put on; and both of these steps ensure that you don't have surface breaking flaws. Then there was a hydrostatic test performed, and then there was another magnetic particle inspection done. All of this to assure that we don't put the vessels in service with large defects, and that's where we are. We think the inspection summary will show that, also.

The next slide on the operations just again is a background to try to point out a little bit of the difference between the BWRs and PWRs.

The BWR, as you're, I'm sure, aware, operates so that the steam region moderates the vessel responses. You have the normal heatups and cooldowns along the steam saturation curve.

One of the key things is the vessel temperatures are normally 100 to 300 degrees above the P-T curve. So we're always in the ductile region, you're always on the upper shelf.

The pressure test after each outage is limiting integrity challenge, and that's done normal operating pressure but at a lower temperature, so it stresses the vessel a little more. But the plant's in cold shutdown and the pressure is carefully controlled and you have the rods in. So if you were going to challenge the vessel, that would be the right place.

The bottom line is, is that if you verify integrity when you've done the pressure test, you're good to go for a cycle. The worst that you could ever postulate happening would be a leak during operation. There would not be any brittle failure. And that's important to know.

CHAIRMAN JACKSON: How does the leak test tell you that?

MR. DYLE: Because if you look at the evaluations we've done, and Dr. Riccardella will get into it in more depth, if you don't fail during the leak test from the structural evaluation, you'll go up and you'll be in the ductile region, so that if you did have anything, the only thing you would have would be a leakage. You wouldn't have a brittle failure of the vessel at operation because your temperature --

DR. RICCARDELLA: The ductility of the material is temperature dependent, and so it tends to be more brittle when it's cold than when it's hot, and we conduct this pressure test or leak test when the vessel is cold.

CHAIRMAN JACKSON: Okay.

MR. DYLE: If you would, turn to Slide Number 13. It's labelled 1997 ISI Summary. And just to give you an update, this is an update from what was originally provided in our report, BWRVIP-05.

We now have responses from 37 domestic units and three international units, and we've got all six designs represented in the results.

Of interest here is back in 1995 when we looked at this, we had over 440 cumulative years of operation.

Obviously, we have more in that range. There's some plants that have now operated seven to ten years, and some of them out in the 25- to 30-year range. So we've got a broad perspective.

There are over 16,000 total feet of category B-A weld that could be inspected, and the category B-A comes from Section 11. Of that, over 8,000 feet has undergone a full code examination, and an additional 700 feet has received a partial code examination where you may have had limitations, could only do one side of exam, or limitations due to transducers.

On the next slide --

CHAIRMAN JACKSON: Let me ask you a question. I'm told that in 1990, that inspections of BWR reactor vessel heads at Quad Cities and Fitzpatrick identified surface cracking and sub-surface flaws. Now, can you discuss the implications of those within the context of the conclusions that you reach?

MR. DYLE: Pete?

DR. RICCARDELLA: Yes. That cracking mechanism was specifically addressed in the evaluation, and you'll see how we did address it when we get into the probabilistic fracture mechanics.

MR. DYLE: It was -- surface cracking wasn't associated necessarily with the actual shell welds; it was in the head region.

Back to slide 14, just going through the summary briefly, as I said, there's over 8,000 feet that's been examined, full and partial code examinations. Of that, over 7,000 feet has been examined using techniques which satisfy Regulatory Guide 1.150.

We asked the EPRI NDE Center to evaluate those techniques and their conclusion was, along with ours, that if a procedure was used that satisfied the Regulatory Guide, there was a high degree of probability that we would find the flaws of concern when we did our inservice examinations. So we're confident that those exams are valid and give us good information about the status of the reactor vessel.

To date, out of all the examinations we've done, there's been 17 indications that required evaluation. There's been others that were acceptable to code evaluation criteria. These 17 were all sub-surface. When you do the fracture mechanics that's required by WB 3600, they are found to be acceptable. And of that, the cumulative length of these indications were 31 inches or .03 percent of the weld length that we've examined.

COMMISSIONER ROGERS: How many of those were in circumferential welds?

MR. DYLE: I would have to go back and look for the exact number. The majority of them are in circumferential welds, which -- but again, they were sub-surface, they were manufacturing type defects, and they weren't anything that occurred inservice. So they would have been there all along historically. I could go back in the report and pull the data out and try to get that number for you.

The last item on the page just simply gets to the cost in man-REMs. The average cost when we did the survey is about $3.3 million per interval, which is a ten-year time frame. The interval comes from Section 11. Some units would be less; some would be significantly higher.

Also, the average exposure associated with this was 12.2 man-REM, and that's just to do the inspection. Those numbers would go up for plants that do examinations from the outside diameter. Also, as the plants age, that number could get worse also.

The conclusion of the survey, shown on Slide Number 15, is that the inspections done to date demonstrate the shell seam welds are free from unacceptable fabrication defects which you would expect from the manufacturing processes that were used. We also found no flaws developing during operation.

This evidence supports the conclusion there's on degradation mechanism that's affecting the seam welds and all of these things combined together supports the reduction in inservice inspections that we're proposing.

The next slide is what we propose to do in the future, and that would be that we'll use a demonstrated technique and procedure. We're going to do the right kind of NDE, we'll make sure it can accurately size and detect the flaws of concern, and it will enhance our ability to do that.

Also, as we do these vertical weld examinations, the way they'll be done is in such a way that when you run across a circumferential weld at the intersection, that weld will also be interrogated at the intersection. What this allows us to do is to continue to collect data on the most risk-significant welds and not do the inspections on those that are not risk significant.

CHAIRMAN JACKSON: Let me ask you a question about terminology.

MR. DYLE: Yes, ma'am.

CHAIRMAN JACKSON: What do you mean when you say a risk-significant weld? Aren't all reactor pressure vessel welds essentially risk significant?

MR. DYLE: I think when Dr. Riccardella gets through, you'll see that there are orders of magnitude difference between the vertical seam welds and the circumferential seam welds.

CHAIRMAN JACKSON: That may be the case, but are you telling us that we should believe that circumferential welds are not risk significant? That's your basic position?

DR. RICCARDELLA: I think, first off, understand that certainly a failure of either vertical or circumferential welds is significant, and that's not our point here at all.

What we really want to get to is the risk contribution that's made by doing or not doing inspections of these welds which is coupled to the probability of circumferential welds actually failing. We're certainly not here to tell you that it's unimportant that circumferential welds fail. That would be significant.

MR. DYLE: It's a relative contribution, yes.

That concludes --

CHAIRMAN JACKSON: So you don't mean the risk significance of the weld; you mean the probability of failure of the weld?

MR. TERRY: Right. And we're talking about the risk significance of the decision to inspect or not inspect. That's really the key point here.

DR. RICCARDELLA: The probability of failure is so small as to make the risk insignificant.

MR. TERRY: I think Dr. Riccardella, when we get to his presentation, you'll understand more precisely where we're coming from.

MR. DYLE: That concludes my remarks, unless you've got any questions about that. Dr. Riccardella, who was one of the primary authors and did the fracture mechanics evaluation, is next.

COMMISSIONER ROGERS: Well, I have a question. I don't know where the best place is, but what about the possibility that the weld materials of the circumferential and the vertical welds are not the same? What could be the implications of that possibility?

DR. RICCARDELLA: In our analysis, we've taken into account statistically the possible variability in the properties of both types of welds. We've analyzed the probability of failure considering the variability in the material properties, and as you see, the results come out -- the results that come out are very striking.

COMMISSIONER ROGERS: All right. Why don't you go ahead.

DR. RICCARDELLA: What I will present is an overview of the methodology that we used in conducting this probabilistic fracture mechanics evaluation, some key features of the analysis and conservatisms in the analysis as well as just a quick overview of the results and conclusions.

As has been mentioned, the details of this analysis were presented in this BWRVIP report which was submitted to the staff in September of '95. That was followed by a two sets of requests for additional information which we responded to. I think that the overall volume of paper submitted on this topic was probably about four inches thick worth of response to the RAIs, and our understanding is that all of the technical questions on our analysis methods and conclusions have been answered and that there are no technical issues remaining unresolved on this analysis.

On the next slide, I'll talk a little bit further about the inherent flaw tolerance of BWR and specifically the differences between a PWR and a BWR in this area.

One of the major points is that the BWR vessel is about twice the diameter of a PWR vessel. This creates a much larger annulus of water between the core and the vessel, and the result is lower irradiation fluence in the vessel and, therefore, lower irradiation embrittlement.

The reference temperature, that is the brittle to ductile reference temperature for a BWR varies from -- at end of life varies from 60 to 150 degrees F versus almost twice the value, 300 degrees F, for a PWR. As a result, the material remains ductile. This is for both longitudinal and circumferential welds. The material remains ductile during all normal and transient operating conditions.

This results in an inherent flaw tolerance for longitudinal seam welds for the limiting pressure test condition and the ASME code quarter-inch reference flaw of a safety factor of four against brittle fracture, which is more than twice -- which is twice the code required safety factor of two.

It also leads to the fact that a through-wall crack that's ten times as long as it is deep does not exceed the fracture toughness of the vessel even in the worst irradiated beltline region.

These first two points are made for longitudinal seam welds. Circumferential cracks exhibit even higher safety factors. This is because fundamentally, the pressure stress in a circumferential weld is half the stress in a longitudinal weld.

You've asked about potential service degradation mechanisms. Two that immediately come to mind are fatigue and stress corrosion cracking.

Fatigue is relatively inconsequential in the beltline and in the shell region of a BWR. The vessel system cycling events are very slow and the fatigue usage resulting from these events is very low. There is no rapid cycling or severe thermal fatigue cycling mechanisms that are applicable to the BWR vessel shell region.

Stress corrosion cracking you mentioned the Quad Cities had -- it's definitely a concern in BWRs, both for stress corrosion crack initiation in the cladding as well as the potential for stress corrosion crack growth in the low alloy steel vessel material. The SCC in the cladding has been observed in the field. The SCC growth in the low alloy steel material has been observed only in the laboratory; it hasn't been observed in the field. But both of these mechanisms were specifically addressed in the probabilistic fracture mechanics analysis.

On the next slide, I show an overall schematic of the analytical approach. I think you can read this. Basically it's a Monte Carlo probabilistic fracture mechanics evaluation technique where we select samples from a weld, either from a longitudinal seam weld or from a circ weld. I show here we're sampling an axial or longitudinal weld. A crack is assumed to exist in that sample, and the probability of that crack comes from two sources as shown in the arrows leading to the upper box on the right-hand side, probability of crack size.

We have included both the probability of a manufacturing defect existing in the vessel in accordance with the standard Marshall distribution. This is the distribution that is -- the well known distribution that's been known in PTS evaluations and has been verified with respect to destructive examination of the Midland vessel.

In addition to that, we take into account the potential for cracking to initiate in the cladding, and so we have two potential sources of cracks -- of cracks being distributed in this sample that we selected.

Then, with operating time, we consider the potential for crack propagation, again in a probabilistic manner considering IGSCC crack growth data and the stress distribution both due to normal operating stresses plus potential clad stresses, and then we have the ability to superimpose upon this the inspection or non-inspection.

So we can have certain -- depending on what percentage inspection we assume, we can have certain of these samples that come through the Monte Carlo analysis subjected to inspection and others not inspected, in which case, if we consider inspection, then we superimpose a probability of detection on that inspection and so then we have a remaining probability that this crack will exist, and then we make a comparison of the resulting crack size to the critical crack size, and in doing that, we look at the initial material properties, RTNDT, the possible variation of copper and nickel content in the weld, and the fluence versus time in the weld. So we make a time comparison of K versus KIC.

This is the basic analytical technique that we use to address this problem.

The next two slides, I talk about the key features of the analysis, and I will point out that the starting point for this analytical methodology was the method developed by the NRC to address PWR pressured thermal shock, namely the VISA code which was developed at Battle Northwest -- at Northwest Laboratories.

This includes a probabilistic treatment of the vessel fracture toughness and the radiation embrittlement concerns; the assumed fabrication defects in the vessel, specifically the Marshall distribution with all of the -- all of the defects in the Marshall distribution were artificially moved to the vessel ID surface, which is conservative from the standpoint of a radiation embrittlement, but we did this to be -- and also conservative with respect to stress corrosion crack growth, because that's where the corrosive environment is. We did this to be consistent with the NRC methodology for PTS.

As in the VISA code, it's a multiple random variable, Monte Carlo analytical approach that we used.

We did have to add -- on the next slide -- some features to the methodology to make it specific to analyze BWR vessel ISI, and those include some items I've already mentioned: the treatment of stress corrosion crack initiation in the cladding; the treatment of stress corrosion crack growth in the low alloy steel; the effects of periodic inservice inspection. And because the resulting probabilities are so low, we couldn't just use a brute force Monte Carlo technique. I mean, you'll see in some cases we would have had to take 10 to the 40th iterations. So what we did is we implemented an importance sampling technique out of the literature to speed up and basically to make the calculations feasible.

These are the new features that we added in the analysis. I should mention that we did, for the features that are consistent with the current VISA code methodology, we did benchmark our methodology against the VISA code, show that we got essentially equivalent results, and that benchmarking is documented in the submittals that we made.

On the next slide -- I'm sorry. Previous slide, please.

Another key feature of the analysis is, you know, as you go through these Monte Carlo iterations, a sample either progresses to failure or it doesn't, and the probability of failure is the number of samples out of the total which have progressed to failure.

But what we found was that there were two types of failures that were falling out of the analysis. One is the crack would just grow to the point where we can't analyze it anymore. It got to be 80 or 90 percent through-wall. But we still haven't reached a point where K exceeds K1C. We still haven't predicted a fracture. This is what we would call a leak scenario.

The second type is that somewhere during that crack propagation, due to the combination of a large flaw and a low fracture toughness condition, you would predict K exceeds K1C, and therefore we would predict a brittle fracture.

What we found was the overwhelming majority of cases, even where we did predict failure, were leakage type failures. Something like, you know, 99 out of every 100 failures that we predicted in the analysis were leaks, and only occasionally did we predict a brittle fracture type failure, and when we did, that occurred during the system leak test.

As Robin mentioned earlier, the critical condition from the standpoint of a low pressure stressing of this vessel is the leak test, which is conducted in a cold condition when the reactor is in cold shutdown.

CHAIRMAN JACKSON: So you're arguing that leak before break for the reactor vessel is acceptable?

DR. RICCARDELLA: Absolutely. And it --

CHAIRMAN JACKSON: Why is that acceptable?

MR. TERRY: That's not our argument. I think our argument --

DR. RICCARDELLA: We're doing inspections. We're saying that the analysis demonstrates that if -- in the very unlikely event that we're going to have a problem with this vessel, that that problem would be a leak, not a break. And you will see a little bit further when I present the results exactly how that manifests itself.

Let me just identify some of the conservatisms in the analysis. They are listed here. I have already mentioned the flaws in the Marshall distribution, even though they're generally expected to be distributed through-wall, we've pushed them all to the ID surface.

We have included a conservative treatment of stress corrosion cracking in the cladding. Basically what we said is if our analysis predicts stress corrosion cracking in the cladding, we instantaneously assume that that cladding is through-wall. We take no credit for time for the crack to propagate through the cladding.

We also arbitrarily assume that it lines up with one of these Marshall type manufacturing defects; that is, we haven't assumed that -- as soon as we predict that the cladding is violated, we assume that it's violated over the entire inside surface of the vessel and, therefore, the Marshall defects will be exposed to the BWR environment and will propagate by stress corrosion.

The rates of stress corrosion cracking in the low alloy steel are based on earlier test data which are shown to be very conservative. More recent test data really shows no stress corrosion crack growth in the low alloy steel, but still we based the analysis on the more conservative data.

As I already mentioned, we have used conservative vessel fracture toughness and radiation embrittlement correlations.

On the next slide, I have a plot, a typical plot of the results of a probabilistic fracture mechanics analysis. There are three curves on this plot. The upper horizontal dash line represents the PTS screening limit; that is, the vessel failure probability that is inherent in the NRC's PTS screening limit.

Then I show two curves. The upper curve designated by triangles is the probability of leakage, and then the lower curve is the probability of actual failure. This is the point that I was alluding to earlier. All of the BWR vessel probabilities are lower than the PTS screening limit, but the probability of a break is much, much lower, it's several orders of magnitude lower versus the PTS -- versus the probability of a leak.

Also, I would address that all of the probabilities shown on this chart are for longitudinal seam welds. We can't even plot the probability of failure or leakage associated with a circumferential weld because it's so many orders of magnitude lower than these.

CHAIRMAN JACKSON: Where is the uncertainty? I mean, these show these as point curves, but whenever you do a probabilistic analysis, you know, there's a certain uncertainty in that analysis, and where would that show up in these curves?

DR. RICCARDELLA: You know, in terms of analytical uncertainties, we have repeated these analyses over and over and we show that they're accurate to within plus or minus a factor of two. I'm not sure if that's what you're asking about, or if you're asking about, you know, potential uncertainties for things that we haven't considered, you know, that we haven't considered in the analysis.

CHAIRMAN JACKSON: I'm asking you about both.

DR. RICCARDELLA: Okay.

CHAIRMAN JACKSON: I mean, there's a certain uncertainty that gets propagated through a probabilistic analysis, and any time you have a probability distribution, --

DR. RICCARDELLA: Yes.

CHAIRMAN JACKSON: -- okay, you're really not talking just simple multiplication or carrying through of point values; you have to recalculate what the distribution looks like.

DR. RICCARDELLA: That's true.

CHAIRMAN JACKSON: And so --

DR. RICCARDELLA: Yes. Those uncertainties are within a factor of plus or minus two on the probability of failure. But, you know, the main point that I would like to make is that these curves are for longitudinal welds, and we're not talking about changing anything for longitudinal seam welds. I would like to make that point with the next slide, which is a table.

In this case, what we've looked at, in this table, the effect on probability -- both probability of failure and probability of leakage of the current requirements, that is the essentially 100 percent of all welds, versus the proposed program, which is essentially 100 percent of seam welds, of longitudinal welds. We have broken this down by the contribution of irradiated longitudinal welds, unirradiated longitudinal welds, and circ welds. And the plot that I showed earlier is what gave the number, for example, irradiated longitudinal seam welds, a probability of failure of 5.68 times 10 to the minus 8. That --

CHAIRMAN JACKSON: With what confidence?

DR. RICCARDELLA: Let's see. I would say within an accuracy of plus or minus a factor of two, but --

CHAIRMAN JACKSON: But with what confidence?

DR. RICCARDELLA: I haven't got a confidence number, confidence interval right at my fingertips.

CHAIRMAN JACKSON: Okay.

DR. RICCARDELLA: But the point is, whatever the confidence, it's exactly the same under the proposed program because we haven't changed anything on longitudinal seam welds when we go from the current requirements to the proposed program. We're talking about the exact same inspection. And likewise, for the unirradiated portion of longitudinal seam welds. We're not proposing any change.

Where we're talking about a change is in welds for which, to the best that we can calculate it -- and here I'm not going to state much confidence in this value other than to state that it's extremely low. We calculated a number of 10 to the minus 40th for the contribution to probability of failure from circumferential welds; many, many orders of magnitude less than that from longitudinal welds. We basically had trouble in any of our Monte Carlo iterations showing a failure, predicting a failure due to a circumferential crack in a circumferential weld.

So what we're saying is that the probability of failure, both failure or leakage, are both already lower than the PTS screening limit and they don't change at all with our proposed program.

So the conclusion slide basically just restates this point. The calculated vessel failure probability is already orders of magnitude lower than the PTS screening limit. This is based on conservative analyses; they could actually be lower if we took some of the conservatisms out of the analysis. The proposed change in inspection scope has an insignificant impact on the already small failure probabilities.

MR. DYLE: Thank you, Pete.

Just a couple of slides and I'll turn it back over to Carl for his closing remarks.

If you look at the slide for impact of implementing the shell weld recommendations, and again, from looking at the probabilistic fracture mechanics, as Pete pointed out, we're not changing anything on the longitudinal seam welds. So comparing apples to apples, there's no change in risk with the program regarding those. But we are talking about removing the circumferential welds, but we don't believe there's any realistic change in the plant safety or risk by not examining those circumferential welds.

Also, we can save at least 200 man-REM in exposure by reducing the number of inspections we do, and that number can go higher for the plants that do OD examinations. As the plants get older and become more contaminated, that number will be greater, also. But that's just from the survey that we've done of what it takes to do the inspections.

There is no consideration in this number for craft support like insulators, scaffold builders and things of that nature. This is just associated with performing the inspections.

CHAIRMAN JACKSON: Do you use similar techniques for doing these inspections as the Japanese use in their reactor pressure vessels?

MR. DYLE: To the best of our knowledge, yes. I know they are working on developing some new tools that we're watching. I believe you may have seen one of them demonstrated at the EPRI NDE Center on one of your visits, and we're eager to see how well that works out. As yet, that has not been done in the field and we're not sure what limitations there will be. But yes, we are eagerly looking for that.

Also, one other thing is we tried to do this in a generic sense in a hope that we could reduce the number of requests for exemptions and relief requests that the staff would have to deal with, because there are so many plants that will not be able to fully meet the rule. They're going to have to deal with exemptions, and this would reduce a number of those.

Finally, there is a significant cost savings to the industry to implement this which would save in excess of $50 million.

CHAIRMAN JACKSON: Commissioner Dicus?

COMMISSIONER DICUS: The 200 man-REM, is that total for all plants?

MR. DYLE: That's total for all plants for one ten-year interval, yes.

The next slide on the current status, where we think we are today with this, we have submitted our technical documentation in the form of the VIP report. We've responded to the staff's RAIs, we provided additional calculations and information on the NDE techniques.

We submitted a request for a technical alternative that's currently pending, and we think we've resolved the technical issues and are awaiting a response to that technical alternative, and that's where we believe we are today.

With that, I'll turn it over to Carl.

MR. TERRY: Thank you, Robin.

In closing, again going back over what we've told you, the BWR vessels were fabricated free of large defects. Robin went over the degree of inspections that were done during the course of that fabrication.

We also talked about the survey results of the ISIs that have been done to date, and they indicate no significant flaws.

In summary, we've looked at about a mile and a half of weld. We found less than three feet of indications, and those were sub-surface indications and are not service-related type flaws.

As far as BWRs, the cold pressure test that we do generally at the end of the outages is the limiting BWR condition. Certainly a failure at any time is not good, but certainly that's -- that's certainly the least risk significant time if a failure were to occur.

ISI of the circumferential welds is really of little value. We see no impact on safety by not doing these inspections, and that's really what's shown by the probabilistic fracture mechanics work that we've done.

As far as the cost savings for reduced inspections, they are substantial with no measurable increase in risk. The inspection recommendations are consistent with what we believe is the right focus, which is to focus the industry and regulatory resources on those issues that really add value from a safety standpoint.

Our alternative specifically is, again, to inspect essentially 100 percent of the axial welds, longitudinal welds, and zero percent of the circumferential welds.

Finally, in closing, by adopting the proposed alternative, the BWR utilities will continue to perform a substantial amount of inspections on the RPV shell welds.

We see no predicted leakage or failure for circumferential welds, and I would point out here that this is something that is unique to the BWRs as far as this condition. The continued inspections of circumferential welds does not add any measurable safety benefit, while it offers substantial savings on the order of 200 man-REM and $50 million for the utilities.

Rapid adoption of this is really critical. We are coming for most plants or a number of plants to the end of this current ten-year interval. This proposal, by the way, is applied for the interval inspections; however, we are coming to the end of the current ten-year interval, making the current review and request for exemption particularly critical and, therefore, we request the Commissioners' approval of this proposed alternative.

CHAIRMAN JACKSON: Commissioner Rogers?

Commissioner Dicus?

COMMISSIONER DICUS: One quick question. You're meeting with ASME, I understand, or you have met with them? Could you just very quickly characterize what has come out of those meetings?

MR. DYLE: In our discussions, the item has been discussed at task group and working group and sub-groups responsible for this issue, and the code case, which is based on the report of doing 50 percent of the longitudinal seam welds and zero of the circumferential, has passed all the way to that point. It is at subcommittee and it is waiting a letter ballot. I'm responsible for writing a white paper to go with that for the members of subcommittee to vote on that.

I have reason to believe there will be a large majority of positive votes there because most of the members also had a chance to vote on this and review the story as it came up through the various committees. And we've deferred writing the white paper so we could roll in any information that might come forward from this meeting so that the code committee is fully aware of everything that's been done.

CHAIRMAN JACKSON: Commissioner Diaz?

COMMISSIONER DIAZ: Just a couple of comments. Obviously, this is a highly technical issue. We certainly appreciate you bringing it up to the attention of the Commission. But I kind of feel inadequate at judging the technical merits of it.

I do believe there is some substantial benefit from addressing the issue again and trying to have the staff, you know, make an additional analysis on your proposal. I certainly don't feel that I can, at this point, address the technical issues on it.

CHAIRMAN JACKSON: Commissioner McGaffigan?

Well, thank you very much.

We will hear from the NRC staff.

MR. TERRY: Thank you.

CHAIRMAN JACKSON: We know who you are.

MR. THOMPSON: I was afraid of that. You know where we live.

CHAIRMAN JACKSON: Mr. Thompson, please.

MR. THOMPSON: Thank you, Chairman Jackson. Good afternoon, Chairman Jackson and Commissioners. Thank you for the opportunity to discuss the staff's position on augmenting examination requirements for boiling water reactor pressure vessels, as we spelled out in our commission paper, SECY 97.88.

At the table with me from NRR is Sam collins, director of NRR; Tim Martin, the acting associate director for technical review; Jack Strosnider, chief of the materials and chemical engineering branch and, from the office of research, Michael Mayfield, chief of the electrical, materials and mechanical engineering branch.

First I would like to thank Mr. Terry, Mr. Dyle and Dr. Riccardella as well as the other members of the BWR vessel and internal projects for their extensive discussion and evaluation that went into the development of their report on BWR reactor pressure vessels shield weld inspection recommendations. Although our judgments differ on how to use the results of their effort, this is an excellent example of their proactive effort in working with the Staff to develop appropriate requirements for inspection and repair of BWR internals, including the BWR core shrouds, jet pump assemblies, core spray piping as well as a number of other BWR internal components and systems. We believe that these cooperative efforts will resolve safety issues and they benefit everyone.

The staff has carefully reviewed the industry's report and agree that it contains substantial technical arguments for deducing the scope of BWR pressure vessel weld examinations. However, we believe that this reduction should be for inspections following the initial base line inspection that is required by both our regulations and the ESM code.

Our focus today is on the integrity of the reactor vessels, the one component for which there is no redundant safety system. It is vital that its integrity be maintained.

Historically, our ability to predict component degradation has not been perfect. Also, the ASME consensus has evolved over time and currently requires 100 percent examination of the reactor pressure vessel belt line welds every ten years. Today, the staff's presentation by Mr. Strosnider will focus on the need to maintain the defense in depth and to validate the assumptions of the industry's probabilistic model.

I would like to turn the rest of the briefing over to Mr. Strosnider.

MR. STROSNIDER: Thank you. Good afternoon.

First, I would like to indicate that, as Mr. Thompson said, in fact I would like to reemphisize that the industry analysis has provided some substantive arguments for reducing the scope of inspections. So you are not going to hear a general condemnation of their analysis. All right.

But I am going to go through some issues that the Staff considered that led us to conclude that it is appropriate to perform a base line examination before we consider this sort of reduction. Those are the things that I want to focus on.

Specific areas for discussion are listed in the first viewgraph. I want to talk a little bit about the safety significance of the vessel, the rule which you have probably heard enough about now to understand what its intention was, the need for inspections, some discussion about the NRC and ASME inspection philosophies, visions that do exist for relief or alternatives and then our conclusions.

On the next viewgraph talking about safety significance, stated quite simply the assumption is that the reactor pressure vessel failure is an incredible event. Quite frankly, when I got ready to present this particular slide, it was a little difficult for me because we just take that as a given that pressure vessel failure is not something that is credible. The engineered safety features of the plant are not designed to cope with reactor pressure vessel failure. They are not specifically designed for that, either catastrophic failure or leakage. So the consequences of such an event have not really been fully evaluated.

Pressure vessel integrity must be maintained at the highest level of quality and nobody is questioning that statement. An important part of that, Staff's position is that an important part of that is maintaining defense in depth and that is accomplished through inspections and evaluation of inspection results to understand the current condition of the reactor vessel and any potential future degradation modes.

Moving on to the next viewgraph, just a little bit more about the augmented inspection rule. Going back in history to the early to mid-'80s, relief had been granted to the boiling water reactors for performing some of the code required examinations. These were granted under 5055(a) of the regulations. The main reason was the inability to access these locations. The tooling just wasn't available.

However, and the Staff recognized the small amount of inspection that was being performed and, also, at the same time, advances in inspection capability that had occurred, and some of this in particular was overseas where we found that people were doing more examinations, and also recognition of some viable degradation mechanisms that I will talk about later, the decision was to promulgate this rule.

Did require expedited implementation of inspections. This is basically what was required by the ASME, except on a faster schedule because of the concern that time had gone by without any significant inspections. It revoked all the prior reliefs that had been granted and, as I indicated, these were granted largely on the basis that they were just physically unable to do the examinations and it was related to tooling.

Some of the units at that time had inspected less than 10 percent of the shell welds and that is still true today. Even though, as you heard in the earlier presentation, there has been a fairly substantial sample of welds inspected, there are plants out there that have not looked at 10 percent of the shell welds in their plants. I'm sorry, have looked at 10 percent or less.

So the rule was promulgated in '92. The one major comment, public comment that was received on the rule was to provide some flexibility in schedule, specifically for those plants that were near the end of the 10-year inspection interval, that they wanted some flexibility in being able to implement this, do some planning and develop the appropriate tooling. So, in fact, the rule was modified such that plants that were within 40 months of the end of the 10-year interval could go to the next interval, next first period of the next interval. A little bit complicated, but we gave them some extra time to implement the inspections.

Also, it was recognized that even with improvements in some of the tooling and inspection capabilities, that there still may be some areas which are inaccessible and we are talking about where there are lugs or attachments physically inside the vessel such that you just can't get to the weld that you want to examine.

Moving on to the next viewgraph, I want to talk about the need for inspections. First, I would point out the purpose of the reason we perform inspections, just in general. We want to identify problems that we didn't anticipate and, as was noted earlier, prediction of degradation in other components has not always been real reliable. Although in hindsight, some of these degradation modes can be explained, it was really inspections and inspection activities that identified them and examples include stress corrosion cracking in BWR piping.

When this issue first came up, it showed up in some small diameter piping and the thought at the time was it wouldn't happen in large diameter piping. Inspections confirmed eventually that it did.

BWR internals, there have been a number of areas where cracking has been found through inspections and that includes, for example, the access cover holes in the inside of the vessel, the core shroud, which has been getting a lot of attention lately.

So one of the things we want to do is identify things we haven't anticipated. The other thing is that the evaluation of the inspection findings is really a proactive way of looking at the condition of the vessel and, as I said earlier, looking at what potential degradation could possibly occur in the future.

So when indications are found, and it was mentioned in some of the recent examinations indications have been found, they were evaluated, they were found acceptable by the code which is what we would expect, that's what we want. But we also look at those and say, well, what kind of degradation is it? Yes, it is subsurface, it is not exposed to the environment. So, you know, we don't have to be as concerned about that as if it were open to the environment and might therefore see some more aggressive growth.

So those are some of the reasons we do the research.

CHAIRMAN JACKSON: Let me ask you a question. Is the code meant to be predictive? I mean, is there an established relationship between code-identified degradations and failures?

MR. STROSNIDER: I would say the answer to that is no. There is -- there is work going on now in the risk informed arena which I think is taking into account more looking at what areas as susceptible and what the consequences are. But I think when some of the early code inspection requirements were developed, it was largely just go out and do a sample across the system. For example, look at 25 percent of the reactor cooling system welds, class one welds, pick those and that should be an adequate sample to tell us if there are any problems.

CHAIRMAN JACKSON: Commissioner McGaffigan?

COMMISSIONER McGAFFIGAN: Could I ask, why wouldn't sampling work in this instance, when their probabilities are ten to the minus fortieth, I haven't seen those since I was studying neutrino cross-sections some time ago.

CHAIRMAN JACKSON: Yeah, we know about those.

COMMISSIONER McGAFFIGAN: Which are small.

But why would -- they are proposing no testing of or inspection of the circumferential welds but why -- why wouldn't a sampling technique be adequate?

MR. STROSNIDER: It is a good question. It is one that we have considered. I will get to that, but I will give you a little preview, which is basically that reactor pressure vessels and the reactor pressure vessel welds are not all the same. Okay? You have to realize that there was a discussion about the sort of inspection that was done during fabrication of the vessels. However, that inspection was different, whether it was radiography or surface, in some cases ultrasonic. It changed as the code changed in time. So not all vessels saw the same fabrication inspections.

The welds made in the vessels because of the fabrication process are different. For example, there was a question earlier about are the circumferential welds different than the axial welds. When you look at the process for fabricating these vessels, the ring sections are made up of plates and there is an automatic process once the ring section is laying down the cladding, welding process. Then the rings are welded together and, in most cases, the back cladding as it is called, the cladding over the welds that join the ring sections together, were done manually. So there is a difference.

In the manual welds, what we have seen is that they are not controlled as well, the heat input may be more difficult to control and those may be areas that are more susceptible to degradation. Also, some of the issue that comes up is repair. There have been and it was indicated repairs were made during fabrication.

There are a number of different vendors or shops that were involved in fabricating these vessels. At least four. Some of the vessels actually went through one, two or in one case three of those shops during fabrication. The vessel was partially fabricated, shipped to another vendor for additional fabrication and shipped to another one to be finaled.

So there is a question about whether the welds we are looking at really represent a homogeneous statistical population, to which you could apply sampling. And one of our concerns is that where repair welds may have been made, that those are particular areas that ought to be looked at. And we think the best way to catch that is by doing a one time base line examination.

You know, we have to keep that in perspective. We do not expect that there are significant, huge flaws in these reactor vessels or I would be here taking an even more aggressive decision on this. But we do recognize from the evaluations that have been done that there is the potential that the wrong -- the wrong elements could wind up in the same place. It is a low probability. But we believe that it is appropriate to go confirm the assumptions that are in the analysis and the evaluations to make sure it really is as low as we think it is.

The situation we are talking about, and even in the industry's assessment, they talk about the potential for stress corrosion cracking in the cladding, lining up with some pre -- some fabrication defect that is in the underlying base metal. And perhaps if you go on beyond that and say, well, this was the area of a large repair, was the stress relief, post-repair stress relief effective, what kind of environment are you in in a particular plant? If you add all those up in the wrong place, you might have the potential for a viable degradation mechanism. And a large part of our conclusion is we ought to verify that that doesn't exist out there.

CHAIRMAN JACKSON: Commissioner Diaz?

COMMISSIONER DIAZ: Yes, just in the same vein, wouldn't a 100 percent examination of the longitudinal welds provide you with a very reasonable sample of how the pressure vessel is standing up?

MR. STROSNIDER: What I am suggesting is that the circumferential welds and the axial welds are not necessarily the same population of welds because of differences in fabrication.

COMMISSIONER DIAZ: I know, but that is not the question. The question is, wouldn't a 100 percent examination of longitudinal welds give you a very good program to verify at least, you know, a portion of the industry's analysis?

MR. STROSNIDER: I am sure you could make some statistical inferences from that if you understood how many repair welds were in that sample versus how many repair welds are in the circumferential welds, things of that nature.

CHAIRMAN JACKSON: Are you saying that is not known?

MR. STROSNIDER: I would say, number one, it hasn't been analyzed. It would take a tremendous amount of effort to pull out all those records. We also -- one of the bullets on the next viewgraph talks about the concern for undocumented repairs.

I would point out that what we have also concluded is following an initial base line to verify the condition of the vessels that a sampling program may in fact be appropriate depending upon the results of that base line example.

COMMISSIONER DIAZ: Define a base line.

MR. THOMPSON: Our definition was essentially a 100 percent of accessible. Essentially 100 percent.

MR. STROSNIDER: Let's move on to viewgraph number six and some of this I think I may have already covered in response to questions.

I want to point out that inspections have identified degradation in reactor pressure vessels and these are some of the instances that, in fact, were called out in the backfit analysis that supported promulgation of the rule.

At Hatch One, there was some pre-service ultrasonic testing done. This was actually in the industry report, which identified defects in the recirculation to shell weld nozzles that required repair so they had to be ground out and repaired.

COMMISSIONER DIAZ: I'm sorry, I couldn't hear you.

CHAIRMAN JACKSON: Hatch One.

MR. STROSNIDER: Yes, at Hatch One during fabrication inspections, ultrasonic testing did identify defects in the recirculation nozzle to shell weld that exceeded -- from what I can read it exceeded the code acceptance criteria and required repair. So there were defects in some of these vessels during fabrication. There were repairs made. And there were varying degrees of inspection.

COMMISSIONER DIAZ: But a nozzle is always a high stress point so it is not the same as the rest of the vessel.

MR. STROSNIDER: True, but this was not service induced. This was fabrication. And it may be a more difficult spot to weld, that's true.

The state of the art inspection methods have identified indications requiring code evaluation. I have heard mention of Brown's Ferry did inspections in 1993. They were using state of the art inspection methods. Fifteen indications required evaluation by code. They would not have been evaluated under the old inspection procedures but they were under the new, detected and evaluated under the new procedures. They were found acceptable; they were subsurface.

In 1995, Pilgrim also performed a state of the art inspection. They found no indications requiring flaw evaluation and this is the information we have available. I wanted to point that one out because in terms of the reactor vessels being similar and there are differences, these were in fact made by different vendors, different results from the inspections.

With regard to viable degradation mechanisms existing, first, it is a given that the BWR environment is an aggressive environment. It can support crack growth. Certainly in stainless steel, we have seen this in piping and internals. Ferritic, as was indicated, some of the early data show that stress corrosion could be supported in some of the ferritic base metal. Some of the more recent data says no, there is some mixed results on that.

With regard to actual experience, there was a mention of the Quad Cities Unit Two, indications that were found in 1990. These were not in a shell weld, they were in the flange, the head weld. There were 34 surface flaws found during that inspection. The longest one was 30 inches long. It penetrated, at its deepest point, through the cladding and about two-tenths of an inch into the heat effective zone in the base metal. So about seven-tenths of an inch deep.

CHAIRMAN JACKSON: Is there a difference between the, you know, are there sufficient differences between the construction of the reactor vessel head and the reactor pressure vessel itself to make the head more susceptible to these degradation mechanisms?

MR. STROSNIDER: Using the same welding processes, there may be some difference, perhaps, in how easy the fit-up is and I can't say there is anything particularly or -- I don't know, staff is shaking their head no difference.

I can't really add anything beyond that.

COMMISSIONER DIAZ: The environment is not the same.

MR. STROSNIDER: No.

COMMISSIONER DIAZ: There is a different environment in the head.

MR. STROSNIDER: There is a different environment.

That is certainly true, in that you are in a steam environment in the head.

I just comment, we got into looking at differences in environments on the core shroud where we thought all the cracking was going to be up high because of the more aggressive environment and it didn't turn out that way.

What you have to remember is you have a lot of competing parameters in developing and sustaining cracking and it includes the environment, it includes the stresses, it includes the material properties and it -- you have to be careful in trying to assume you know how all those are going to come together.

So that was the experience at Quad Cities. It was evaluated that that flaw was found that it was acceptable as it was found. There was some grinding done on it to smooth it out and then it was found acceptable for continued service. But the grinding, of course, reduces the stresses there and makes it less susceptible to any continued growth.

The backfit package that went along with the rule in 1992 referenced some experience with stress corrosion cracking in feedwater nozzles siphons where again cracking was initiated in stainless steel but grew into the ferritic material. It occurred at Brunswick and also at a Chinese plant.

Finally, this one was interesting, Fitzpatrick, this was also I believe in 1990. They found a surface crack in the reactor vessel head. This was higher in the head than at the flange weld. Interesting. This was an unclad head. There was no stainless steel cladding on this vessel.

When they went back and took a close look at this, it turned out that the surface indication that was there was some sort of fabrication scratch or defect. It happened to be in the area of some subsurface slag inclusions that were about 12 inches in length. The maximum depth at that location was about two inches.

Those appear to have been fabrication, not service induced defects but one of the things that we heard and that we have been considering is what's the likelihood that the wrong situations could add up at the same time. This is in a location where, in all likelihood, had it been clad it would have been done manually and those are areas where we know there is a greater susceptibility to stress corrosion cracking of the clad and if that sort of crack joined up with this sort of preexisting defect, it might be a concern.

As you heard, the analysis does make an assumption, okay, that in fact if you grow through the clad, you sample from a distribution and have that match up with some fabrication defects. One thing I point out here to recognize is a lot of the Morte Carlo analysis is often assumes independence of all these different parameters. In this case, they have tried to address that but I think the point is there may not be independence because some areas are just more susceptible to having these adverse conditions.

COMMISSIONER DIAZ: May I make a comment?

CHAIRMAN JACKSON: Please.

COMMISSIONER DIAZ: You know, this is not my area. I am here, you know, apples and oranges. You are mixing flanges and heads that are carbon steel that are not, you know, stainless steel with defects from manufacture and putting all that together in the context of the reactor pressure vessel. And I don't think they are the same thing, you know, from the little of what I know. I think they are completely different issues.

I mean, we know that there is a stress corrosion cracking issue with boiling water reactors and we have always known that. They have taken care of that.

Now, the question is, have we ever found a deficiency or degradation in a reactor pressure vessel, in a boiling water sufficient to say, hey, this is not acceptable and you have to do something about it? Have we ever found one?

MR. STROSNIDER: I am describing what has been found and the inspections that were performed.

COMMISSIONER DIAZ: No, you have not said that there is one that has actually been significant to the point that it is not acceptable to the staff or, at least, that is what I heard.

MR. STROSNIDER: That's correct.

COMMISSIONER DIAZ: So all of them have been acceptable to the staff so the staff concluded that they did not really degrade to the point that it posed a safety question; is that correct?

MR. STROSNIDER: That is absolutely true and as I indicated earlier, that is our expectation. I hope that we never find and I don't think we will find flaws in a reactor vessel that compromise its integrity.

COMMISSIONER DIAZ: The if is not the issue. The question is, have you found one and I guess your answer is no.

MR. STROSNIDER: No, we have not found one.

COMMISSIONER DIAZ: Thank you.

MR. COLLINS: Commissioner, I guess it is important to know that I think part of what Jack is trying to stress is because we have not done the 100 percent examinations we have not established a base line which would indicate what the potential is for that to occur other than an in-process issue, which would be a leak. And, of course, that has been avoided.

COMMISSIONER DIAZ: I understand the difference.

COMMISSIONER ROGERS: Just before you leave that, though, it does seem to me that you have -- you do have a total disagreement with the industry on this question of whether there is a viable degradation mechanism for welds. I mean, you have cited a number of examples of degradations that you have found but I didn't hear you mention any in a weld.

Their statement, their concluding statement was, an absence of degradation mechanisms substantiates vessel integrity, dot, dot, dot. And you are saying there is a viable degradation mechanism and so it seems to me there is a total conflict on that issue.

MR. STROSNIDER: Yes, and the real issue here, first of all, there is a degradation mechanism which everyone acknowledges in the stainless steel cladding. There are cracks that have been found, service induced in the cladding. The question is, will it grow into the ferritic base metal, all right? And as I indicated, and I think as was indicated in their presentation, some of the early data indicate that you could grow cracks if you have a high enough driving force. Some of the more recent data says, no, you wouldn't expect that.

All right.

We have not seen an example where it has really been given a chance. Probably the closest was quad cities.

That was found early in the inspection and the defect was corrected. The analysis that the industry did did suggest that if you had cladding flaws growing into significant fabrication defects where you get a high enough driving force, something like 30 KSI root inch applied stress intensity factor that there could be a mechanism.

So, as I indicated, the data are not all that clear, all right? And given that uncertainty, our conclusion is that we should go take a look.

The last thing on this viewgraph I wanted to talk about was the potential for undocumented repairs. I am not sure how much difference it makes whether they are documented or not in terms of the potential for degradation although, as was said, there was a lot of work done, a lot of procedures in place to document this sort of thing.

However, the research office says the reactor vessel down at Oak Ridge National Laboratory which we have been doing examinations on, looking at welds, looking at density of defects and that sort of thing. And one of the things they found in that reactor vessel was a significant repair to one of the shell welds which was not documented. It was not in the documentation that we acquired with the vessel. I don't know if Mike wants to expand on that at all but --

MR. MAYFIELD: Just that it turned out to be a quite large defect or repair, in some cases according to the laboratory running as much as three-quarters of the way through the wall thickness. It spanned several feet. The only indication in any of the documentation is that there were -- there was a repair based on high-low mismatch that you get when you line up the two rings but there was certainly no suggestion of the extent of this repair in any of the documentation that we acquired.

COMMISSIONER ROGERS: Would that have been done at the time of fabrication?

MR. MAYFIELD: Yes, sir.

COMMISSIONER DIAZ: Of course, repairs are part of the industrial process.

MR. MAYFIELD: Yes. And, in and of itself, we weren't bothered by it. It is just that it is one more bit of information that feeds into this puzzle.

CHAIRMAN JACKSON: Okay. Let's move on.

MR. STROSNIDER: Moving on to viewgraph number seven, again, the need for inspections, the conclusion that we reached here is that we think again a base line inspection, which I will define as essentially all the welds they can get access to and take a look at is appropriate in order to verify the low probabilities that we are seeing.

As I said earlier, you are not going to hear a condemnation, general condemnation of the analysis that was done by the industry. We think it had a lot of insights and that there is a lot of merit to it but we do think there are enough questions, looking back at the history, that it is appropriate to go do that sort of base line examination.

What we are looking for is what we consider a very low probability event. But we are talking about the reactor pressure vessel and we feel that the safety significance of the vessel warrants doing that sort of inspection.

Having done that, we do think that the analysis that has been presented, after we look at the results of that base line, provide perhaps good basis for going through a sampling inspection and that could mean significant impact on the resources expended in subsequent intervals.

Going on to slide number six, just a discussion on the NRC and the ASME code inspection philosophy. You heard some of this. Basically, the code has evolved over time. It currently does require 100 percent inspection, essentially 100 percent inspection, which means 90 percent recognizing some of the limitations. Anything less than 90 percent requires actually some granting of relief or alternative by the NRC under 5055(a).

I should point out that some of the NRC certainly was a proponent in some of these code changes that went to larger examination percentages. But our position has been consistent with the ASME code for some time which, actually, since 1975 has required at least 100 percent base line examination. Essentially 100 percent.

You heard that the industry is pursuing with the ASME codes some changes in these requirements. In fact, we encourage that in one of our letters, particularly with regard to those inspections that might be performed subsequent to a base line.

CHAIRMAN JACKSON: Is that to say then that if the code is changed, the staff will change its position?

MR. STROSNIDER: No.

But we will certainly assess the changes in the code and see through our rulemaking process if that is the appropriate answer. And, as I said, we have encouraged after a base line examination the notion that the evaluations performed support a sampling sort of inspection.

CHAIRMAN JACKSON: Where in the process is the BWR owner's group in its request to change the code? I mean, how far along?

MR. STROSNIDER: As Mr. Dyle indicated, it has been through several committees. I am not sure I can give you all the way up through the subcommittees.

CHAIRMAN JACKSON: I mean, how much longer do you think this is going to take? Is it hard to predict?

MR. STROSNIDER: I don't know. Is there someone who was at the code meetings from the staff that can address that?

Gil Millman?

MR. MILLMAN: Pardon my laryngitis; I have been at code meetings for the last week.

This particular code case did come up to the Subcommittee on Nuclear In-Service Inspection last December. At that time, Mr. Dyle withdrew it and on the basis that it would go forward only when there was a technical basis document supporting it and so it waits at the subcommittee for that action.

CHAIRMAN JACKSON: I see.

Commissioner Diaz?

COMMISSIONER DIAZ: I don't know whether the question is valid any more but you said no to whether this type of change in the position, you know, regarding the ASME. Does that mean the staff's position is independent of the ASME?

MR. STROSNIDER: Well, in general.

COMMISSIONER DIAZ: In total?

MR. STROSNIDER: In general, the process that we go by is the Code of Federal Regulations endorse industry codes and standards. Sometimes we endorse those with some exceptions or with some additions and my comment is basically that we will not only observe but we have people who will participate in the code activities and make sure that our concerns are identified early.

When the code reaches conclusion, either in a code case or in a change to the code, we will assess that as part of the rulemaking process and see how it would be endorsed in the regulations.

But we don't -- it is not a given that we just take it the way it's --

CHAIRMAN JACKSON: Have there been cases where the staff -- the staff's position has not been consistent with the code and the staff has come out with a more conservative position?

MR. STROSNIDER: Yes.

MR. COLLINS: Yes.

CHAIRMAN JACKSON: Okay.

MR. STROSNIDER: One other comment is we did -- we went out last week basically a poll looking to see what the positions are internationally with regard to this type of inspection. We have three responses so far, one from MITI, the Ministry of Industry and Trade in Japan. They require 100 percent each 10 years, every 10-year interval --

CHAIRMAN JACKSON: Of vertical --

MR. STROSNIDER: Of the shell welds.

CHAIRMAN JACKSON: Of all of them?

MR. STROSNIDER: Yes, longitudinal and circumferential.

COMMISSIONER ROGERS: BWRs as well as PWRs?

MR. STROSNIDER: Yes.

We do understand also that there is some discussion with their industry about possibly changing that at some point.

The Spanish do 100 percent of axial and circumferential each 10 years and also in Sweden they do 100 percent.

I would point out that a lot of this is driven by what is in the ASME code and that is an international code so there are other countries who follow that and in fact do follow pretty much what the NRC is doing.

I would also point out, though, that Sweden has been leading, perhaps, in the area of risk-informed in-service inspection and they still do this sort of inspection.

Viewgraph nine, talking about granting relief and I think the main point I wanted to make here is that we recognize that certainly with the current tooling there are some limitations as to what can be inspected.

In the industry submittal, they talk about, however, some of the improvements that have been made and they talk about an inspection in 1983 at a BWR 3 facility where they were able to get 41 percent of the circumferential welds and 52 percent of the longitudinal.

In a more recent 1993 examination, this was at a BWR 4 so there might be some slight differences, but they achieved 78 percent of the circumferential welds and 91 percent of longitudinal. So there has been progress in terms of the tooling and the technology.

You also heard mention the device that has been demonstrated at the EPRI NDE center that was developed by the Japanese. You understand there is at least one U.S. company looking at commercializing that in the U.S. and it is basically a submersible device which is, as I understand, self-propelled and can move around. It is very thin. The word we got is it could get probably 90 percent of the welds in most of the vessels out there. I don't know how far that is from actual implementation. We know there have been demonstrations at the NDE center and they are ongoing in Japan.

I think the point here is that progress can be made in terms of improving the inspection technology. And some of this, again, we haven't seen all the details but it sounds like it would have reduced setup time and even personnel exposure as opposed to putting big manipulators on top of the vessel, being able to put in some submersible which you can operate from some distance.

COMMISSIONER DIAZ: That is not commercially available in this country. Will it be in the next five years?

MR. STROSNIDER: Not right now, no. And I don't know. Like I said, the industry is following that. As Mr. Dyle indicated, they are aware of it.

COMMISSIONER DIAZ: In other words, it is a long term thing. It is not something that is going to be available next year?

MR. STROSNIDER: I don't know what the schedule is. As I said, it has been demonstrated and is -- there are some in-vessel demonstrations going on in Japan.

CHAIRMAN JACKSON: I've seen it. EPRI is working on it.

MR. STROSNIDER: So with regard to granting reliefs and, as I pointed out, the rule does -- and it specifically included, and I am looking at slide number 10 now --

CHAIRMAN JACKSON: Let me go back to slide nine. You say the industry proposal is for NRC to grant a large number of reliefs from requirements based largely on probabilistic assessments and I note that in your paper, the Staff stated that it had concluded that rejection of the project's probabilistic arguments to support authorization of inspection alternatives, et cetera, is consistent with the Commission policy on the use of probabilistic risk assessment.

Can you explain, you know, the basis of that statement and is the staff's current position risk informed and can you relate that to ongoing efforts with respect to a risk-informed ISI and IST, okay?

MR. STROSNIDER: A statement that was in the Commission policy, let me see if I can actually get the -- well, this I can just read. This was a quote from the Commission policy statement that use of probabilistic risk assessment methods, the staff used the safety goals in making regulatory decisions regarding backfitting new generic requirements but not to make specific licensing decisions including granting relief from unnecessary requirements.

That is a quote from the policy statement.

MR. COLLINS: It is on page 4.

MR. STROSNIDER: August 19, 1995. I was looking for the policy statement but it is in the paper.

But I guess I would also point out that, to try to keep this in context, the evaluation that was submitted by the industry is really not full-blown risk assessment. It doesn't go out to the consequence stage administration that sort of thing. It doesn't assess what happens if you have a leak, for example, and it does include some deterministic arguments with regard to fabrication and that sort of thing. So it is sort of a mix.

But we thought that was an issue that we at least questioned when we looked at it and said, well, is this an appropriate basis for granting release and it would be release for essentially all the BWR plants. Does it maintain defense in depth as we think is appropriate?

CHAIRMAN JACKSON: Commissioner McGaffigan?

COMMISSIONER McGAFFIGAN: The difference is 30 orders of magnitude between longitudinal welds and circumferential welds and in their analysis. You have gone through a long explanation as to why there might be something there that no one has foreseen and therefore you want to inspect them all but 30 orders of magnitude, have you looked at that difference and that analysis and found a flaws in it?

MR. STROSNIDER: There are no specific problems that we have identified in the way the analysis -- in the modeling itself. It has to do with looking at assumptions, input parameters and, quite frankly, our experience in trying to predict what may or may not happen. I refer back to some probabilistic assessments on piping and that sort of thing where people failed to take into account loadings and they found degradation. They weren't in the model.

So one of the reasons you do inspections is to find out what you are not smart enough to put in your model.

As I said, you are not going to hear a

condemnation of the analysis that they have done and it does show a significant difference.

MR. THOMPSON: Commissioner, to get to your point, as Jack explained, we are dealing primarily with the up-front assumptions that you predicate that risk questions on and the uncertainties that are involved as articulated by the staff here with the fabrications and the records and the history and the repairs and the lack of a base line. Lacing that base line, the staff really is missing a key piece of information to predicate the change under 5055(a) which is allowable if you are able to meet the statement of an acceptable level of quality and equivalent acceptable level of quality and safety. That is essentially where we are.

MR. STROSNIDER: On viewgraph number 10, I just briefly indicate that, as I said earlier, that the rule acknowledged when it was promulgated that there could be some areas that are difficult to access and in fact the wording in the augmented inspection rules where people are unable to do inspections, they may propose alternatives.

Quite frankly, it takes a little bit of thinking but it is our assessment of the industry's proposal, we think, that proposal can be used to justify some of these areas where you just can't access them. But we also think that in terms of defense in depth that you should do the scope of the inspection that you can do.

So, the conclusions are that we -- again, we think the industry's analysis has merit. It has added a lot of insights to pressure vessel integrity issues. We have concluded for the reasons we just discussed that a base line examination of those welds that can be accessed should be performed. That the report and the work they've done can be used to support relief where, in fact, they just can't access some of these welds and that future modifications to the inspection requirements may be appropriate after completion of the base line.

It would be our plans to complete that in a safety evaluation that we could issue in probably about six weeks or so.

CHAIRMAN JACKSON: Let me ask you three questions quickly. If uncertainty isn't in part influencing the staff's position, are there alternatives such as pilots or targeted implementation or some other strategy to provide some additional information to support the staff's position?

MR. STROSNIDER: Well, I think the question came up. One obvious thought that comes up there is could you deal with this on a sampling basis and draw inferences from the sampling basis. And --

CHAIRMAN JACKSON: That is one example. But one could take a -- and I guess this is a different -- it depends on what you mean by sample. You could take all the plants and have a sample of areas. You can take a subset of plants and do 100 percent. That's a sample. Et cetera, et cetera.

Have you given some thought to these kinds of alternatives?

MR. STROSNIDER: Well, we thought about that and, again, the conclusion we reached was do as much as you can at this point and then look at a sampling basis because after you have gone through and looked at all the welds and confirmed the -- you know, really given confirmation of the quality that was there when they were originally fabricated and, as we pointed out, there have been improvements in inspection techniques, we can see things today we couldn't see then, you have confirmed that in fact you don't have all the wrong conditions at the same location, you have confirmed that there is something you didn't anticipate, then you basically we think can go to a sampling method where you are monitoring for any sort of degradation that might show up.

CHAIRMAN JACKSON: So basically you want a database which you believe you don't have at this stage of the game, is that the point?

MR. STROSNIDER: Yes.

CHAIRMAN JACKSON: Have you discussed this at all with the ACRS?

MR. STROSNIDER: We have not had any recent discussions. The ACRS was involved in the original promulgation of the rule back in '92. They looked at that and supported it, as I understand it.

CHAIRMAN JACKSON: Do you intend to document the technical basis for your rejection of the industry group's proposal then in a safety evaluation report?

MR. STROSNIDER: Right. We would document the discussion basically that I just gave you and a safety evaluation which I would expect to complete in about six weeks.

CHAIRMAN JACKSON: And what kind of time line are we operating under?

MR. STROSNIDER: Well for, as I say, issuing the safety evaluation, I would put a target of about six weeks.

It is important, and I think the industry pointed out, when you look at the rule and where the plants are in their inspection intervals, that many of these examinations would need to be performed in the next year or two and the planning has to be done, equipment has to be available. So we recognize that a decision of position needs to be made sooner rather than later.

CHAIRMAN JACKSON: Okay, is that it?

MR. THOMPSON: That concludes our presentation. We would be prepared to answer any questions.

CHAIRMAN JACKSON: Commissioner Dicus, questions, Commissioner Diaz?

COMMISSIONER DIAZ: Yes, I just have a quick comment. Knowing the difference between these reactors and the difference between circumferential and longitudinal welds, I actually don't see, although you might have it in six weeks, a basis for denial of the industry request. It seems to me like 100 percent longitudinal inspection program with some beef behind it, I mean, to get it done in a very, you know, reasonable period of time will provide a good base line. And from there, during that period of time, we might be able to develop a program that will provide some basis for the circumferential welds.

I actually see no technical information that has been presented that says this is, you know, unreasonable or is not adequate protection of health and safety. Because most of the things that have been presented are peripheral to the main issue of how the pressure vessel is attacked and how are the -- you know, the differences in stresses between circumferential and longitudinal welds.

So unless I see something different, I don't see why a program that actually addresses 100 percent longitudinal wells as soon as possible, will not be a good base line to consider, you know, than the circumferential welds.

CHAIRMAN JACKSON: I would like to thank the representatives of the BWR Vessel and Internals Project and the NRC staff for briefing the Commission regarding the issues associated with the staff's technical position regarding alternatives for augmenting inspection of the reactor vessel. As I mentioned in my opening remarks, you know, the Commission is not a commission of technical experts and so, I don't believe in an hour and a half we can sit here and sort through all of that. It is important for the Commission to understand aspects of the technical basis for the staff's position so that if there are any policy issues involved, the Commission can make informed decisions.

It is also important for the public and the industry and as well, as the discussion today has revealed, the international regulatory community to understand the staff's positions. So given the recognition of the important role that the reactor pressure vessel does play in implementing the Commission's defense in depth philosophy but given that you have even said yourself that the project has proposed some technically sound discussions for implementing a reduced scope augmented inspection, the staff should complete, on an expedited basis, the development of the safety evaluation report on the Boiling Water Reactor Vessel and Internal Project proposed alternative and to consider whether there is a tiered approach to getting at the issue. And if it is not technically possible, you should tell us that.

This safety evaluation report would then serve as the staff's documented and defensible basis for resolution of the issues and any -- document any open issues and would facilitate any commission decisions if they are appropriate on any of the related policy issues.

So unless there are any further comments, we are adjourned.

[Whereupon, at 4:50 p.m., the meeting was concluded.]

CERTIFICATE

This is to certify that the attached description of a meeting of the U.S. Nuclear Regulatory Commission entitled:

TITLE OF MEETING: MEETING WITH BOILING WATER REACTOR VESSEL AND INTERNALS PROJECT AND NRC STAFF - PUBLIC MEETING

PLACE OF MEETING: Rockville, Maryland

DATE OF MEETING: Monday, May 12, 1997

was held as herein appears, is a true and accurate record of the meeting, and that this is the original transcript thereof taken stenographically by me, thereafter reduced to typewriting by me or under the direction of the court reporting company

Transcriber: [signature]

Reporter: Mark Mahoney

NRC STAFF'S POSITION ON AUGMENTED EXAMINATION REQUIREMENTS FOR BOILING WATER REACTOR PRESSURE VESSELS PURSUANT TO 10 CFR 50.55a(g)(6)(ii)(A)

May 12, 1997

Jack R. Strosnider, NRR

SUBJECTS FOR DISCUSSION

- SAFETY SIGNIFICANCE
- AUGMENTED INSPECTION RULE
- NEED FOR INSPECTIONS
- NRC/ASME INSPECTION PHILOSOPHIES
- RELIEF PROVISIONS
- CONCLUSIONS

SAFETY SIGNIFICANCE

- RPV Integrity Must be Maintained to the Highest Level of Quality
- Engineered Safety Features are Not Designed to Cope with RPV Failure
- Defense-in-Depth Maintained by Inspections and Evaluation

10 CFR 50.55a AUGMENTED INSPECTION RULE

- Required Expedited Implementation of Augmented Inspections of RPV Shell Welds
- Revoked Industry-Requested Reliefs from Inspection Requirements Previously Granted
- Incorporated 1989 Edition of ASME Code, which Required Inspection of All RPV Shell Welds

NEED FOR INSPECTIONS

- To Ensure Quality of Components by Monitoring for Unanticipated Degradation and Assessing Significance of Defects

- Prediction of Degradation in Other Components has Not Been Highly Reliable

  - BWR Piping and Internals

NEED FOR INSPECTIONS (Con't.)

- Inspections Have Identified Degradation in RPVs

  - State-of-the-Art Inspection Methods Have Identified Indications Requiring Code Evaluation

  - Viable Degradation Mechanism for RPV Welds Does Exist

  - Potential Exists for Undocumented Repairs

NEED FOR INSPECTIONS (Con't.)

- Inspections Support Analytic Assumptions and Identify Potential Unexpected Degradation Phenomena
  - Validate Flaw Distribution Assumptions
  - Validate Assumptions Regarding Degradation Mechanisms

NRC / ASME CODE INSPECTION PHILOSOPHY

- ASME Code has Required *at Least One "Essentially 100 Percent"* RPV Weld Inspection Since 1975
- 1989 Edition of ASME Code Requires Essentially 100% Examination of Beltline Welds Every Inspection Interval
- NRC Staff's Position Consistent with ASME Code
- BWROG Pursuing Changes to ASME Code
  - ASME has Not Approved Changes

GRANTING RELIEFS FROM THE REGULATIONS

- 10 CFR 50.55a Incorporates Mechanisms for Granting Reliefs from Rule Where Alternatives Can be Shown to Provide an Acceptable Level of Quality and Safety

- Industry Proposal is for NRC to Grant Large Number of Reliefs from Requirements of 50.55a Based Largely on Probabilistic Assessments

GRANTING RELIEFS FROM THE REGULATIONS (Con't.)

- Staff Position

  - Technical Bases Insufficient to Support Eliminating Baseline Examinations

  - Limited Reliefs May be Necessary Where Licensees are Unable to Perform Examinations at Inaccessible Locations

  - Changes in Inspection Scope May be Appropriate After Base Line Examinations Completed

NRC STAFF'S CONCLUSIONS

- BWR Licensees Should Complete at Least One Examination of All RPV Beltline Welds Capable of Being Inspected to Validate Analysis Assumptions

- BWRVIP-05 Report Can Be Basis for Granting Limited Alternatives Under 10 CFR 50.55a(g)(6)(ii)(A)(5)

- Future Modifications to Inspection Requirements May Be Appropriate After Completion of Baseline Examinations

BWRVIP Commission Briefing

BWR Reactor Pressure Vessel Shell Weld Inspection Recommendations

May 12, 1997

NRC Offices

Rockville, MD

Agenda

- Introduction
- BWR Vessel Shell Weld Integrity
- Inservice Inspection
- Probabilistic Fracture Mechanics Evaluation
- Summary

Introduction

- BWRVIP proposed alternative for BWR RPV shell weld inspections is based on:
  - sound and thorough technical evaluation
  - deterministic and risk evaluation
- Proposed alternative would result in significant savings to the BWR industry with no measurable impact on safety – exposure to radiation as well as [illegible]
- Rapid industry adoption is critical
- Request Commissioners approval of proposed alternative

History

- Rule promulgated in September 1992
- Formation of BWRVIP in July 1994
- Initial meeting with NRC to discuss technical approach in August 1995 because we couldn't meet the rule + needed relief -
- Detailed report transmitted to NRC in September 1995
- BWRVIP/NRC management meeting in July 1996. No unresolved technical issues.
- BWRVIP requested authorization of a technical alternative in October 1996 as a legal solution.

BWRVIP Proposed Alternative

- Current RPV shell weld inspection requirements call for 100% inspection of all circumferential and longitudinal welds
- BWRVIP proposed alternative:
  - inspect essentially 100% of axial welds
  - inspect 0% of circumferential welds
- Can be handled as a technical alternative with current regulations

Code and Regulatory Background

- ASME Code inspection requirements
  - Currently 100% ⇒ both welds
  - Treats BWRs and PWRs the same - inappropriate
  - Treats Axial and Circumferential welds the same
- Regulatory requirements
  - Augmented Rule requires 100%
  - Treats BWRs and PWRs the same - inappropriate
  - Treats Axial and Circumferential welds the same
- Most BWRs physically cannot meet rule

Code and Regulatory Background

- Intent of this effort is to focus industry and regulatory resources on issues significant to safety -- what is the right thing to do
  - safety/risk
  - exposure
  - regulatory impact
  - cost

BWR Vessel Shell Weld Integrity

BWR Fabrication

- Vessel Fabrication
  - Shells are rolled plates with vertical and circumferential connecting welds
  - Three seam welding processes
  - Two cladding steps
  - Seam welds and cladding PWHT at least once (Post Weld Heat Treatment)
  - Repair welds, when needed, made and inspected as carefully as original welds

BWR Fabrication

- **Vessel Fabrication Inspections**
  - **Multiple inspection techniques used**
    - » Radiography (RT) - any crack, >3/4 inch inclusion
    - » Ultrasonic (UT) - any crack, >3/4 inch subsurface
    - » Mag. particle (MT) - >1/16 inch linear, >3/16 inch rounded
    - » Penetrant (PT) - >1/16 inch linear, >3/16 inch rounded
  - **Typical weld would get RT and MT, then PT after cladding, then MT again on outside, and often UT, after preservice hydrotest**
  - **BWR vessels entered service free of large defects, especially precluding surface defects**

BWR Operation

- Operating Characteristics of BWR
  - Internal steam region moderates vessel responses
    - » Normal heatups and cooldowns along steam saturation curve
    - » Pressure and temperature coupled during transients; no PTS
    - » Vessel temperatures normally 100-300°F above P-T curve
  - Pressure test after outage is limiting vessel integrity challenge
    - » Normal operating pressure, temperature per P-T curve
    - » Plant in cold shutdown, pressure carefully controlled
  - Integrity during pressure test assures integrity during next operating cycle

Inservice Inspection

1997 BWRVIP ISI Summary

(Updated from BWRVIP-05)

- **Responses received for 37 domestic units and 3 international units**
- **All 6 BWR designs represented**
- **Results from 36 units**
  - 441 cumulative years of operation (24 units as of April 1995)
  - 16,384 total ft. of category B-A RPV weld length
  - 8,151 ft. has undergone full code examination
  - an additional 700 feet has undergone partial code examination

BWRVIP

1997 BWRVIP ISI Summary

- **Full plus partial examinations equal 8,851 ft. or 54% of total possible weld length**
- **At least 7,557 ft. (85%) of sample met R.G. 1.150 (46% of total possible)**
- **17 indications required evaluation**
  - All were subsurface
  - All met IWB-3600 acceptance criteria
  - Cumulative length of indications was 31 in. or just 0.03% of total weld length examined
- **Substantial cost and man-REM exposure**
  - Average cost of $3,300,000 per unit each interval
  - Average exposure of 12.2 man-REM per unit each interval (significantly higher for examinations from the OD)

BWRVIP ISI Survey Results

Conclusions

- Inspections performed to date have demonstrated that reactor pressure vessel shell seam welds are free from unacceptable fabrication defects and that no flaws have developed during operation.
- The evidence supports the conclusion that there are no degradation mechanisms that have affected the reactor pressure vessel shell seam welds.
- When combined with the high quality of original fabrication, an absence of degradation mechanisms substantiates vessel integrity and supports the reduction in inservice inspections.

Future Inservice Inspection

- **Use demonstrated technique/procedure**
  - Further enhance detection
  - More accurately size indications
- **Will interrogate circ/axial intersection**
- **Continue to collect data on risk-significant welds**

Probabilistic Fracture Mechanics Evaluation

- Overview of Methodology
- Key Features of Analysis
- Conservatisms in Analysis
- Results and Conclusions

BWRVIP

Inherent Flaw Tolerance of BWR Vessels

- **Material Characteristics of BWR vessel**
  - Shroud annulus water reduces fluences to low levels
  - Adjusted reference temperatures, 60-150° F at 40 years
  - Material remains ductile during all normal and transient conditions
- **Inherent Flaw Tolerance**
  - For limiting pressure conditions and a 1/4 T flaw, K_{IC} provides safety factor of *four* against brittle fracture
  - Through-wall axial flaw, $a/\ell = 1/10$, does not exceed K_{IC} at pressure test conditions, even in beltline
  - Circumferential cracks exhibit even higher safety factors

Twice that required by code

Potential Degradation Mechanisms

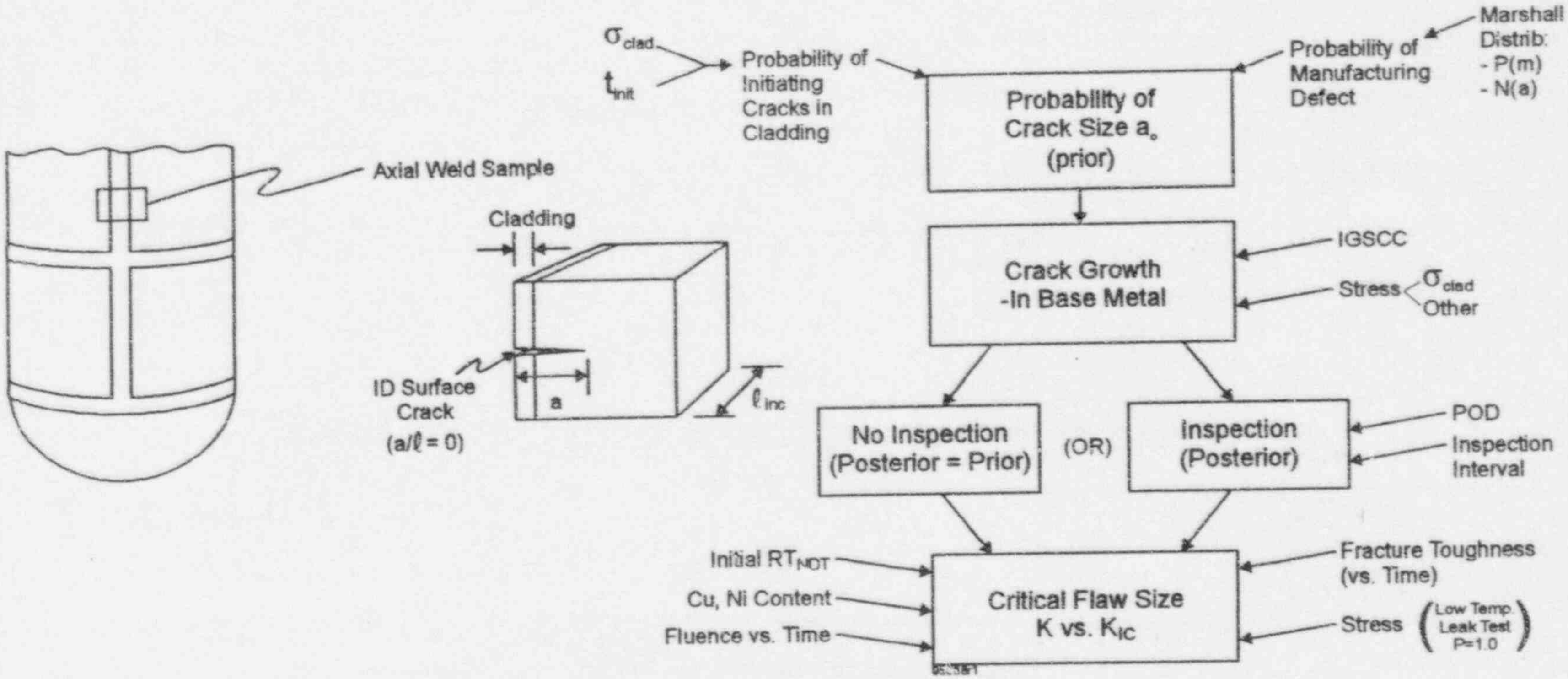
- **Fatigue**
  - System cycling fatigue usage low, rapid cycling not applicable

- **Stress Corrosion Cracking (SCC)**
  - SCC of cladding or low alloy steel (LAS) minor concern in BWR environment

- **These degradation mechanisms specifically addressed in PFM analysis**

BWR RPV SHELL WELD PROBABILISTIC F.M. EVALUATION

(Overview of Methodology)



Key Features of Analysis

- Starting point was methodology developed by NRC for analysis of PWR pressurized thermal shock (VISA code), including
  - Probabilistic treatment of vessel fracture toughness and radiation embrittlement
  - Assumed fabrication defects in vessel (Marshall distribution with all defects arbitrarily moved to vessel ID surface)
  - Multiple random variable, Monte Carlo simulations used to compute vessel failure probabilities

Key Features of Analysis

- Several new features specific to BWR vessel ISI added to methodology
  - Stress corrosion crack initiation in cladding
  - Stress corrosion crack growth in low alloy steel
  - Effects of periodic inservice inspection
  - "Importance sampling" technique to improve the efficiency of Monte Carlo calculations

Key Features of Analysis

- Two types of "failures" addressed in analysis:
  - Crack growth to >80% through wall crack (leak)
  - K_I exceeding K_{IC} under worst case low temperature stress condition, w/radiation embrittlement effects (break)
- The analysis demonstrated an overwhelming tendency for leak-before-break, and limiting condition for breaks is periodic pressure testing, with the reactor in cold shutdown

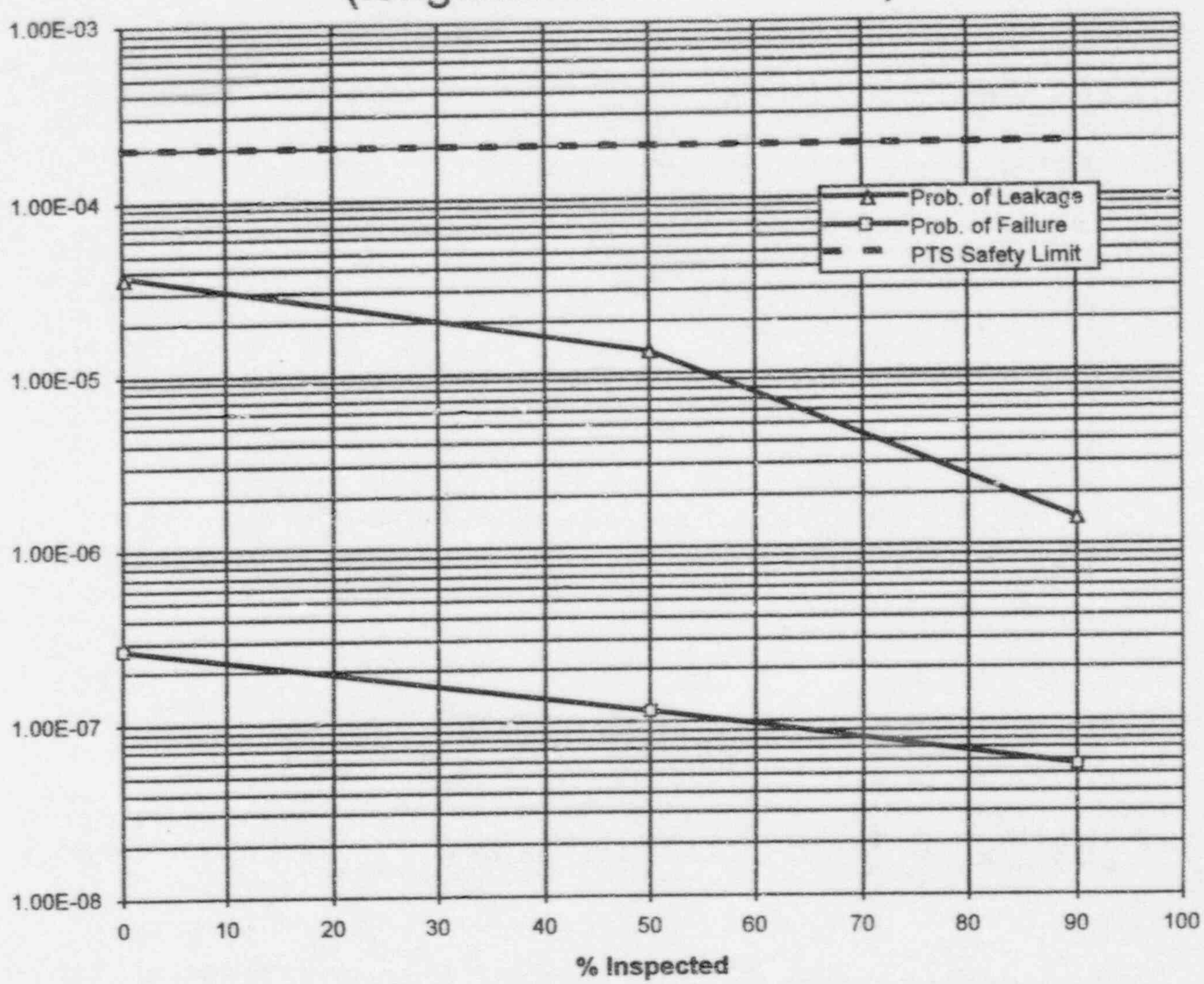
Conservatisms in Analysis

- All flaws assumed to be at ID surface
- Conservative treatment of stress corrosion cracking in cladding
- High rates of stress corrosion crack growth assumed for low alloy steel
- Conservative vessel fracture toughness and radiation embrittlement correlations

BWRVIP

Results of PFM Analysis

(longitudinal seam welds)



Effect of Proposed ISI Program on BWR Vessel Integrity

	Probability of Failure per 40 Vessel Years		Probability of Leakage per 40 Vessel Years	
	Current Requirements[1]	Proposed Program[2]	Current Requirements[1]	Proposed Program[2]
Long. Welds (Irrad.)	$5.68x10^{-8}$	$5.68x10^{-8}$	$1.45x10^{-6}$	$1.45x10^{-6}$
Long. Welds (Unirrad.)	$1.07x10^{-10}$	$1.07x10^{-10}$	$5.01x10^{-6}$	$5.01x10^{-6}$
Circ. Welds (All)	$1.26x10^{-40}$	$1.10x10^{-40}$	$1.94x10^{-22}$	$2.12x10^{-22}$
Totals	$5.69x10^{-8}$	$5.69x10^{-8}$	$6.46x10^{-6}$	$6.46x10^{-6}$

1. 90% Inspection of all Longitudinal and Circumferential Welds
2. 90% Inspection of Longitudinal Welds; Zero inspection of Circumferential Welds

what is your confidence level?

PFM Conclusions

- Calculated vessel failure probability is orders of magnitude lower than the NRC PTS Screening Limit
- Realistic failure probabilities would be even smaller if conservatisms were removed from the analysis
- Proposed change in the inspection scope has insignificant impact on already small failure probabilities

Impact of Implementing Shell Weld Inspection Recommendations

- No change in plant safety/risk
- Reduction in personnel exposure (~200 man-rem)
- Reduction in requests for exemption
- Significant cost savings (>$50M)

Current Status

- BWRVIP documentation submitted to support reduced inspection requirements
  - BWRVIP-05 document submitted
  - Response to RAIs submitted
  - Request for Technical Alternative pending

- Technical issues are resolved

- Awaiting response to request for Technical Alternative

Report Results and Conclusions

- BWR vessels were fabricated free of large defects
- ISI survey indicates no significant flaws
- Cold pressure test is limiting BWR condition
- ISI of circumferential welds is of little value
- Probabilistic fracture mechanics demonstrates very low probability of vessel failure

Report Results and Conclusions

- Cost savings for reduced inspections is substantial with no measurable increase in risk
- Inspection recommendations are consistent with need to focus industry and regulatory resources on issues significant to safety
- BWRVIP proposed alternative:
  - Inspect essentially 100% of axial welds
  - Inspect 0% of circumferential welds

Closing Remarks

- By adopting proposed alternative, BWR utilities will continue to perform a substantial amount of inspections on the risk significant RPV shell welds
- No predicted leakage or failure for circumferential welds
- Continued inspection of circumferential welds adds no measurable safety benefit at a great cost and man-rem exposure
- Rapid industry adoption critical
- Request Commissioners approval of proposed alternative