

**ORIGINAL**  
**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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1 UNITED STATES OF AMERICA  
2 NUCLEAR REGULATORY COMMISSION

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4 MEETING WITH BOILING WATER REACTOR VESSEL  
5 AND INTERNALS PROJECT AND NRC STAFF

6 \*\*\*

7 PUBLIC MEETING

8 \*\*\*

9  
10 Nuclear Regulatory Commission  
11 Commission Hearing Room  
12 11555 Rockville Pike  
13 Rockville, Maryland

14  
15 Monday, May 12, 1997  
16

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

20 COMMISSIONERS PRESENT:

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

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1 STAFF AND PRESENTERS SEATED AT THE COMMISSION TABLE:

2 JOHN C. HOYLE, Secretary

3 STEVEN BURNS, Deputy General Counsel

4 HUGH THOMPSON, Deputy Executive Director for  
5 Regulatory Programs

6 THOMAS MARTIN, Acting Associate Director for  
7 Technical Review, NRR

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

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

12 SAMUEL COLLINS, Director, NRR

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

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

17 PETE RICCARDELLA, Structural Integrity Associates  
18  
19  
20  
21  
22  
23  
24  
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## P R O C E E D I N G S

[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

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

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

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

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

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

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

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

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

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

18 MR. TERRY: Okay. Thank you.

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

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

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

25 As far as the presentation today, going to the

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

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

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

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

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



1 alternative.

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

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

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

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

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

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

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

21           Robin.

22           MR. DYLE: Thank you, Carl.

23           On the Code and regulatory background slide, just  
24 a few key points to make from there. The current Code  
25 requirements are to do the 100 percent of the

1 circumferential and longitudinal seam welds, as Carl  
2 mentioned; however, we believe that's inappropriate because  
3 of a couple of things.

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

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

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

25 So those two situations led us to think there were

1 reasons to look at this from a technical standpoint.

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

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

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

25 Quite frankly, we were surprised at what we came

1 up with and the recommendation that we have, because we  
2 would have thought there would have been more required. But  
3 when you go through the technical evaluation again, we think  
4 what we're proposing is legitimate.

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

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

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

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

18 If you would skip two slides over to slide number  
19 9, labelled BWR Fabrication. Just a couple of real quick  
20 points I would like to make from a background standpoint.  
21 When we went back and looked at this from a fabrication  
22 standpoint, here are some of the items that described the  
23 vessels. It's shells with rolled plates, you have vertical  
24 seam welds and you have circumferential welds.

25 There are three different welding processes that



1 could be used and there are different cladding steps. One  
2 machine clad for most of the shell courses, and then a  
3 manual back clad on the field welds.

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

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

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

19 Typically, if you look at the way these things  
20 were put together, the vessel would get an RT and an MT;  
21 then you have a PT after cladding to make sure the cladding  
22 was put on; and both of these steps ensure that you don't  
23 have surface breaking flaws. Then there was a hydrostatic  
24 test performed, and then there was another magnetic particle  
25 inspection done. All of this to assure that we don't put

1 the vessels in service with large defects, and that's where  
2 we are. We think the inspection summary will show that,  
3 also.

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

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

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

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

22 The bottom line is, is that if you verify  
23 integrity when you've done the pressure test, you're good to  
24 go for a cycle. The worst that you could ever postulate  
25 happening would be a leak during operation. There would not

1 be any brittle failure. And that's important to know.

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

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

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

16 CHAIRMAN JACKSON: Okay.

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

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

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

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

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

12 On the next slide --

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

19 MR. DYLE: Pete?

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

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

1 in the head region.

2 Back to slide 14, just going through the summary  
3 briefly, as I said, there's over 8,000 feet that's been  
4 examined, full and partial code examinations. Of that, over  
5 7,000 feet has been examined using techniques which satisfy  
6 Regulatory Guide 1.150.

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

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

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

24 MR. DYLE: I would have to go back and look for  
25 the exact number. The majority of them are in



1 circumferential welds, which -- but again, they were sub-  
2 surface, they were manufacturing type defects, and they  
3 weren't anything that occurred inservice. So they would  
4 have been there all along historically. I could go back in  
5 the report and pull the data out and try to get that number  
6 for you.

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

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

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

23 This evidence supports the conclusion there's on  
24 degradation mechanism that's affecting the seam welds and  
25 all of these things combined together supports the reduction

1 in inservice inspections that we're proposing.

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

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

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

17 MR. DYLE: Yes, ma'am.

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

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

25 CHAIRMAN JACKSON: That may be the case, but are

1 you telling us that we should believe that circumferential  
2 welds are not risk significant? That's your basic position?

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

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

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

14 That concludes --

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

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

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

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

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

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

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

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

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

24 As has been mentioned, the details of this  
25 analysis were presented in this BWRVIP report which was

1 submitted to the staff in September of '95. That was  
2 followed by a two sets of requests for additional  
3 information which we responded to. I think that the overall  
4 volume of paper submitted on this topic was probably about  
5 four inches thick worth of response to the RAIs, and our  
6 understanding is that all of the technical questions on our  
7 analysis methods and conclusions have been answered and that  
8 there are no technical issues remaining unresolved on this  
9 analysis.

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

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

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

25 This results in an inherent flaw tolerance for



1 longitudinal seam welds for the limiting pressure test  
2 condition and the ASME code quarter-inch reference flaw of a  
3 safety factor of four against brittle fracture, which is  
4 more than twice -- which is twice the code required safety  
5 factor of two.

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

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

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

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

24 Stress corrosion cracking you mentioned the Quad  
25 Cities had -- it's definitely a concern in BWRs, both for

1 stress corrosion crack initiation in the cladding as well as  
2 the potential for stress corrosion crack growth in the low  
3 alloy steel vessel material. The SCC in the cladding has  
4 been observed in the field. The SCC growth in the low alloy  
5 steel material has been observed only in the laboratory; it  
6 hasn't been observed in the field. But both of these  
7 mechanisms were specifically addressed in the probabilistic  
8 fracture mechanics analysis.

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

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

25           In addition to that, we take into account the

1 potential for cracking to initiate in the cladding, and so  
2 we have two potential sources of cracks -- of cracks being  
3 distributed in this sample that we selected.

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

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

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

25 The next two slides, I talk about the key features

1 of the analysis, and I will point out that the starting  
2 point for this analytical methodology was the method  
3 developed by the NRC to address PWR pressured thermal shock,  
4 namely the VISA code which was developed at Battelle Northwest  
5 -- at Northwest Laboratories.

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

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

19 We did have to add -- on the next slide -- some  
20 features to the methodology to make it specific to analyze  
21 BWR vessel ISI, and those include some items I've already  
22 mentioned: the treatment of stress corrosion crack  
23 initiation in the cladding; the treatment of stress  
24 corrosion crack growth in the low alloy steel; the effects  
25 of periodic inservice inspection. And because the resulting

1 probabilities are so low, we couldn't just use a brute force  
2 Monte Carlo technique. I mean, you'll see in some cases we  
3 would have had to take 10 to the 40th iterations. So what  
4 we did is we implemented an importance sampling technique  
5 out of the literature to speed up and basically to make the  
6 calculations feasible.

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

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

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

20           But what we found was that there were two types of  
21 failures that were falling out of the analysis. One is the  
22 crack would just grow to the point where we can't analyze it  
23 anymore. It got to be 80 or 90 percent through-wall. But  
24 we still haven't reached a point where K exceeds  $K_{IC}$ . We  
25 still haven't predicted a fracture. This is what we would



1 call a leak scenario.

2 The second type is that somewhere during that  
3 crack propagation, due to the combination of a large flaw  
4 and a low fracture toughness condition, you would predict K  
5 exceeds  $K_{IC}$ , and therefore we would predict a brittle  
6 fracture.

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

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

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

20 DR. RICCARDELLA: Absolutely. And it --

21 CHAIRMAN JACKSON: Why is that acceptable?

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

24 DR. RICCARDELLA: We're doing inspections. We're  
25 saying that the analysis demonstrates that if -- in the very

1 unlikely event that we're going to have a problem with this  
2 vessel, that that problem would be a leak, not a break. And  
3 you will see a little bit further when I present the results  
4 exactly how that manifests itself.

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

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

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

23 The rates of stress corrosion cracking in the low  
24 alloy steel are based on earlier test data which are shown  
25 to be very conservative. More recent test data really shows

1 no stress corrosion crack growth in the low alloy steel, but  
2 still we based the analysis on the more conservative data.

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

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

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

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

25 CHAIRMAN JACKSON: Where is the uncertainty? I

1 mean, these show these as point curves, but whenever you do  
2 a probabilistic analysis, you know, there's a certain  
3 uncertainty in that analysis, and where would that show up  
4 in these curves?

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

12 CHAIRMAN JACKSON: I'm asking you about both.

13 DR. RICCARDELLA: Okay.

14 CHAIRMAN JACKSON: I mean, there's a certain  
15 uncertainty that gets propagated through a probabilistic  
16 analysis, and any time you have a probability distribution,  
17 --

18 DR. RICCARDELLA: Yes.

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

23 DR. RICCARDELLA: That's true.

24 CHAIRMAN JACKSON: And so --

25 DR. RICCARDELLA: Yes. Those uncertainties are

1 within a factor of plus or minus two on the probability of  
2 failure. But, you know, the main point that I would like to  
3 make is that these curves are for longitudinal welds, and  
4 we're not talking about changing anything for longitudinal  
5 seam welds. I would like to make that point with the next  
6 slide, which is a table.

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

18 CHAIRMAN JACKSON: With what confidence?

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

21 CHAIRMAN JACKSON: But with what confidence?

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

24 CHAIRMAN JACKSON: Okay.

25 DR. RICCARDELLA: But the point is, whatever the

1 confidence, it's exactly the same under the proposed program  
2 because we haven't changed anything on longitudinal seam  
3 welds when we go from the current requirements to the  
4 proposed program. We're talking about the exact same  
5 inspection. And likewise, for the unirradiated portion of  
6 longitudinal seam welds. We're not proposing any change.

7           Where we're talking about a change is in welds for  
8 which, to the best that we can calculate it -- and here I'm  
9 not going to state much confidence in this value other than  
10 to state that it's extremely low. We calculated a number of  
11 10 to the minus 40th for the contribution to probability of  
12 failure from circumferential welds; many, many orders of  
13 magnitude less than that from longitudinal welds. We  
14 basically had trouble in any of our Monte Carlo iterations  
15 showing a failure, predicting a failure due to a  
16 circumferential crack in a circumferential weld.

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

21           So the conclusion slide basically just restates  
22 this point. The calculated vessel failure probability is  
23 already orders of magnitude lower than the PTS screening  
24 limit. This is based on conservative analyses; they could  
25 actually be lower if we took some of the conservatisms out

1 of the analysis. The proposed change in inspection scope  
2 has an insignificant impact on the already small failure  
3 probabilities.

4 MR. DYLE: Thank you, Pete.

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

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

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

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

1 inspections.

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

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

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

20 Finally, there is a significant cost savings to  
21 the industry to implement this which would save in excess of  
22 \$50 million.

23 CHAIRMAN JACKSON: Commissioner Dicus?

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



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

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

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

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

14 MR. TERRY: Thank you, Robin.

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

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

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

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

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

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

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

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

22          We see no predicted leakage or failure for  
23 circumferential welds, and I would point out here that this  
24 is something that is unique to the BWRs as far as this  
25 condition. The continued inspections of circumferential

1 welds does not add any measurable safety benefit, while it  
2 offers substantial savings on the order of 200 man-REM and  
3 \$50 million for the utilities.

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

12 CHAIRMAN JACKSON: Commissioner Rogers?  
13 Commissioner Dicus?

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

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

1 to vote on that.

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

9 CHAIRMAN JACKSON: Commissioner Diaz?

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

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

20 CHAIRMAN JACKSON: Commissioner McGaffigan?

21 Well, thank you very much.

22 We will hear from the NRC staff.

23 MR. TERRY: Thank you.

24 CHAIRMAN JACKSON: We know who you are.

25 MR. THOMPSON: I was afraid of that. You know

1 where we live.

2 CHAIRMAN JACKSON: Mr. Thompson, please.

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

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

15 First I would like to thank Mr. Terry, Mr. Dyle  
16 and Dr. Riccardella as well as the other members of the BWR  
17 vessel and internal projects for their extensive discussion  
18 and evaluation that went into the development of their  
19 report on BWR reactor pressure vessels shield weld  
20 inspection recommendations. Although our judgments differ  
21 on how to use the results of their effort, this is an  
22 excellent example of their proactive effort in working with  
23 the Staff to develop appropriate requirements for inspection  
24 and repair of BWR internals, including the BWR core shrouds,  
25 jet pump assemblies, core spray piping as well as a number

1 of other BWR internal components and systems. We believe  
2 that these cooperative efforts will resolve safety issues  
3 and they benefit everyone.

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

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

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

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

25 MR. STROSNIDER: Thank you. Good afternoon.

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

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

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

20           On the next viewgraph talking about safety  
21   significance, stated quite simply the assumption is that the  
22   reactor pressure vessel failure is an incredible event.  
23   Quite frankly, when I got ready to present this particular  
24   slide, it was a little difficult for me because we just take  
25   that as a given that pressure vessel failure is not

1 something that is credible. The engineered safety features  
2 of the plant are not designed to cope with reactor pressure  
3 vessel failure. They are not specifically designed for  
4 that, either catastrophic failure or leakage. So the  
5 consequences of such an event have not really been fully  
6 evaluated.

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

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

22 However, and the Staff recognized the small amount  
23 of inspection that was being performed and, also, at the  
24 same time, advances in inspection capability that had  
25 occurred, and some of this in particular was overseas where



1 we found that people were doing more examinations, and also  
2 recognition of some viable degradation mechanisms that I  
3 will talk about later, the decision was to promulgate this  
4 rule.

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

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

20 So the rule was promulgated in '92. The one major  
21 comment, public comment that was received on the rule was to  
22 provide some flexibility in schedule, specifically for those  
23 plants that were near the end of the 10-year inspection  
24 interval, that they wanted some flexibility in being able to  
25 implement this, do some planning and develop the appropriate

1 tooling. So, in fact, the rule was modified such that  
2 plants that were within 40 months of the end of the 10-year  
3 interval could go to the next interval, next first period of  
4 the next interval. A little bit complicated, but we gave  
5 them some extra time to implement the inspections.

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

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

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

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

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

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

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

24           CHAIRMAN JACKSON: Let me ask you a question. Is  
25 the code meant to be predictive? I mean, is there an

1 established relationship between code-identified  
2 degradations and failures?

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

13 CHAIRMAN JACKSON: Commissioner McGaffigan?

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

19 CHAIRMAN JACKSON: Yeah, we know about those.

20 COMMISSIONER MCGAFFIGAN: Which are small.

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

24 MR. STROSNIDER: It is a good question. It is one  
25 that we have considered. I will get to that, but I will

1 give you a little preview, which is basically that reactor  
2 pressure vessels and the reactor pressure vessel welds are  
3 not all the same. Okay? You have to realize that there was  
4 a discussion about the sort of inspection that was done  
5 during fabrication of the vessels. However, that inspection  
6 was different, whether it was radiography or surface, in  
7 some cases ultrasonic. It changed as the code changed in  
8 time. So not all vessels saw the same fabrication  
9 inspections.

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

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

1     repairs were made during fabrication.

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

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

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

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

13           CHAIRMAN JACKSON: Commissioner Diaz?

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

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

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

1 industry's analysis?

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

7 CHAIRMAN JACKSON: Are you saying that is not  
8 known?

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

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

19 COMMISSIONER DIAZ: Define a base line.

20 MR. THOMPSON: Our definition was essentially a  
21 100 percent of accessible. Essentially 100 percent.

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

25 I want to point out that inspections have



1 identified degradation in reactor pressure vessels and these  
2 are some of the instances that, in fact, were called out in  
3 the backfit analysis that supported promulgation of the  
4 rule.

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

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

12 CHAIRMAN JACKSON: Hatch One.

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

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

24 MR. STROSNIDER: True, but this was not service  
25 induced. This was fabrication. And it may be a more

1     difficult spot to weld, that's true.

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

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

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

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

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

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

19           I can't really add anything beyond that.

20           COMMISSIONER DIAZ: The environment is not the  
21   same.

22           MR. STROSNIDER: No.

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

25           MR. STROSNIDER: There is a different environment.

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

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

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

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

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

25 Finally, this one was interesting, Fitzpatrick,

1 this was also I believe in 1990. They found a surface crack  
2 in the reactor vessel head. This was higher in the head  
3 than at the flange weld. Interesting. This was an unclad  
4 head. There was no stainless steel cladding on this vessel.

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

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

20 As you heard, the analysis does make an  
21 assumption, okay, that in fact if you grow through the clad,  
22 you sample from a distribution and have that match up with  
23 some fabrication defects. One thing I point out here to  
24 recognize is a lot of the Monte Carlo analysis is often  
25 assumes independence of all these different parameters. In

1 this case, they have tried to address that but I think the  
2 point is there may not be independence because some areas  
3 are just more susceptible to having these adverse  
4 conditions.

5 COMMISSIONER DIAZ: May I make a comment?

6 CHAIRMAN JACKSON: Please.

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

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

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

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

25 COMMISSIONER DIAZ: No, you have not said that

1     there is one that has actually been significant to the point  
2     that it is not acceptable to the staff or, at least, that is  
3     what I heard.

4             MR. STROSNIDER:   That's correct.

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

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

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

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

17            COMMISSIONER DIAZ:   Thank you.

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

25            COMMISSIONER DIAZ:   I understand the difference.

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

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

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

23          All right.

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



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

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

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

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

25 MR. MAYFIELD: Just that it turned out to be a

1 quite large defect or repair, in some cases according to the  
2 laboratory running as much as three-quarters of the way  
3 through the wall thickness. It spanned several feet. The  
4 only indication in any of the documentation is that there  
5 were -- there was a repair based on high-low mismatch that  
6 you get when you line up the two rings but there was  
7 certainly no suggestion of the extent of this repair in any  
8 of the documentation that we acquired.

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

11 MR. MAYFIELD: Yes, sir.

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

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

17 CHAIRMAN JACKSON: Okay. Let's move on.

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

24 As I said earlier, you are not going to hear a  
25 condemnation, general condemnation of the analysis that was

1 done by the industry. We think it had a lot of insights and  
2 that there is a lot of merit to it but we do think there are  
3 enough questions, looking back at the history, that it is  
4 appropriate to go do that sort of base line examination.

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

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

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

22 I should point out that some of the NRC certainly  
23 was a proponent in some of these code changes that went to  
24 larger examination percentages. But our position has been  
25 consistent with the ASME code for some time which, actually,

1 since 1975 has required at least 100 percent base line  
2 examination. Essentially 100 percent.

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

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

10 MR. STROSNIDER: No.

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

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

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

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

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

1     that?

2                 Gil Millman?

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

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

11                CHAIRMAN JACKSON: I see.

12                Commissioner Diaz?

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

18                MR. STROSNIDER: Well, in general.

19                COMMISSIONER DIAZ: In total?

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

1 that our concerns are identified early.

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

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

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

12 MR. STROSNIDER: Yes.

13 MR. COLLINS: Yes.

14 CHAIRMAN JACKSON: Okay.

15 MR. STROSNIDER: One other comment is we did -- we  
16 went out last week basically a poll looking to see what the  
17 positions are internationally with regard to this type of  
18 inspection. We have three responses so far, one from MITI,  
19 the Ministry of Industry and Trade in Japan. They require  
20 100 percent each 10 years, every 10-year interval --

21 CHAIRMAN JACKSON: Of vertical --

22 MR. STROSNIDER: Of the shell welds.

23 CHAIRMAN JACKSON: Of all of them?

24 MR. STROSNIDER: Yes, longitudinal and  
25 circumferential.

1 COMMISSIONER ROGERS: BWRs as well as PWRs?

2 MR. STROSNIDER: Yes.

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

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

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

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

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

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

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

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

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

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



1 years?

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

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

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

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

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

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

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

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

14 That is a quote from the policy statement.

15 MR. COLLINS: It is on page 4.

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

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

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

6 CHAIRMAN JACKSON: Commissioner McGaffigan?

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

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

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

25 As I said, you are not going to hear a

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

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

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

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

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

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

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

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

23           CHAIRMAN JACKSON: That is one example. But one  
24  could take a -- and I guess this is a different -- it  
25  depends on what you mean by sample. You could take all the

1 plants and have a sample of areas. You can take a subset of  
2 plants and do 100 percent. That's a sample. Et cetera, et  
3 cetera.

4 Have you given some thought to these kinds of  
5 alternatives?

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

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

23 MR. STROSNIDER: Yes.

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

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

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

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

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

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

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

23 CHAIRMAN JACKSON: Okay, is that it?

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

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1                   CHAIRMAN JACKSON: Commissioner Dicus, questions,  
2 Commissioner Diaz?

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

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

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



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

13           It is also important for the public and the  
14  industry and as well, as the discussion today has revealed,  
15  the international regulatory community to understand the  
16  staff's positions. So given the recognition of the  
17  important role that the reactor pressure vessel does play in  
18  implementing the Commission's defense in depth philosophy  
19  but given that you have even said yourself that the project  
20  has proposed some technically sound discussions for  
21  implementing a reduced scope augmented inspection, the staff  
22  should complete, on an expedited basis, the development of  
23  the safety evaluation report on the Boiling Water Reactor  
24  Vessel and Internal Project proposed alternative and to  
25  consider whether there is a tiered approach to getting at

1 the issue. And if it is not technically possible, you  
2 should tell us that.

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

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

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

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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: 

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**

NRC Staff's Position

-3-

### **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**

NRC Staff's Position

-4-

## **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**

NRC Staff's Position

-5-

## **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**

NRC Staff's Position

-6-

## **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 Staff's Position

-7-

## **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**

NRC Staff's Position

-8-

## **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**

NRC Staff's Position

-9-

## **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 Position

-10-



## **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**

# **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
- Rapid industry adoption is critical
- Request Commissioners approval of proposed alternative

*exposure to radiation as well as \$*

## 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% *of 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**



BWRVIP

# **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 *Post Weld Heat Treatment* PWHT at least once
  - 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**

BWRVIP

# 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

## **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**

# Inherent Flaw Tolerance of BWR Vessels

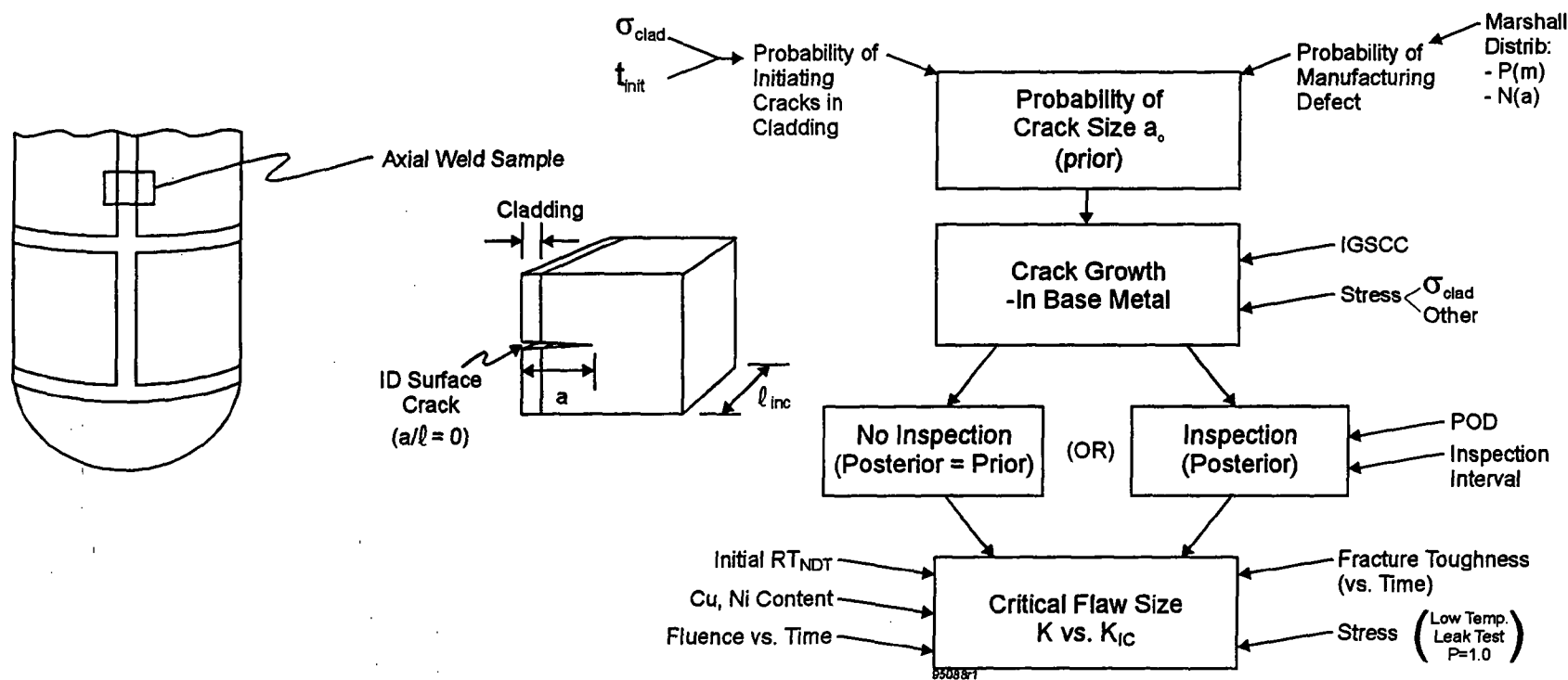
- **Material Characteristics of BWR vessel**
  - Shroud annulus water reduces fluences to low levels
  - Adjusted reference temperatures, 60-150° F at 40 years
  - Material remains ductile during all normal and transient conditions
- **Inherent Flaw Tolerance**
  - For limiting pressure conditions and 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  
required  
that  
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**



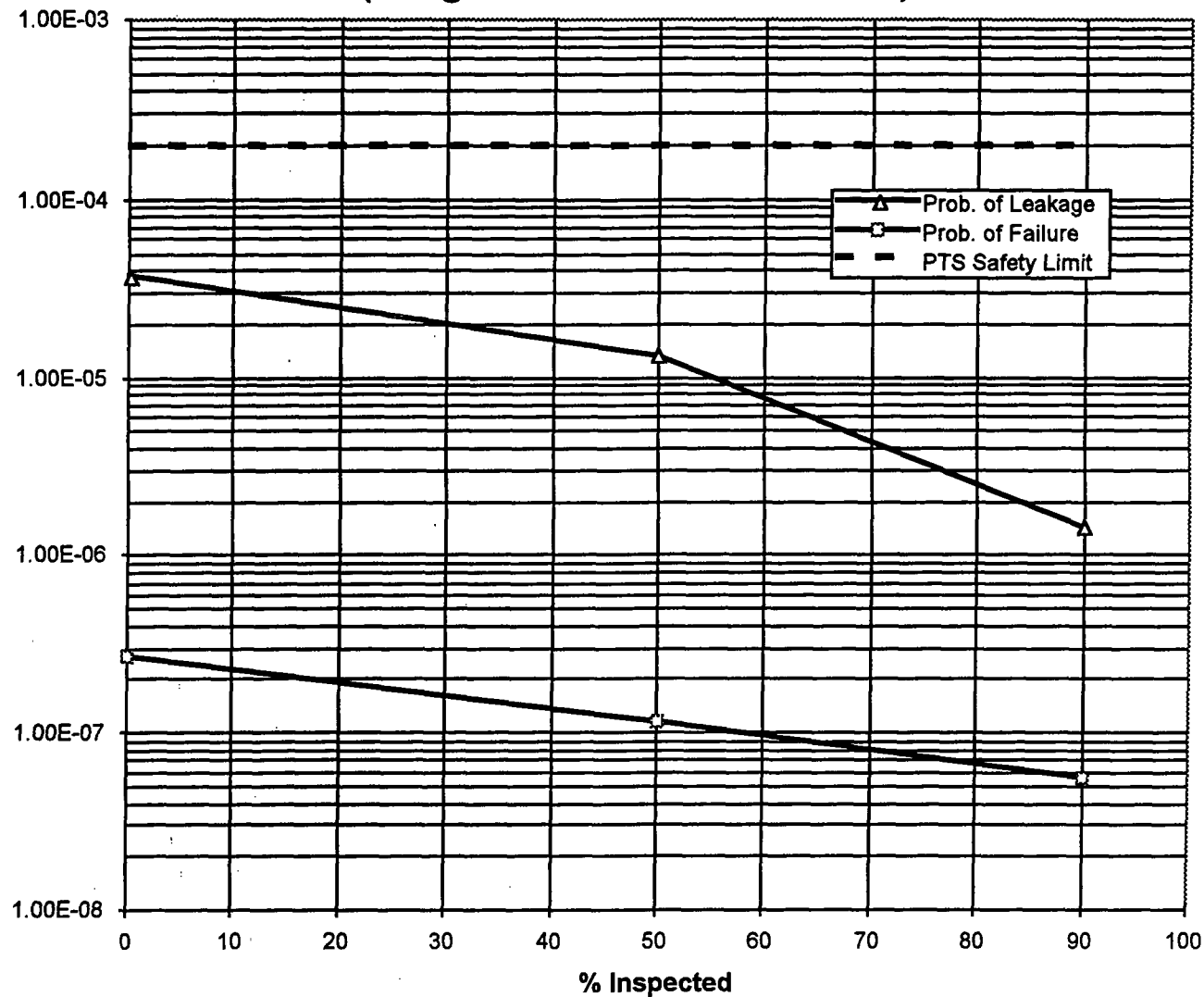
## **Conservatisms in Analysis**

- **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 <sup>1</sup>	Proposed Program <sup>2</sup>	Current Requirements <sup>1</sup>	Proposed Program <sup>2</sup>
Long. Welds (Irrad.)	$5.68 \times 10^{-8}$	$5.68 \times 10^{-8}$	$1.45 \times 10^{-6}$	$1.45 \times 10^{-6}$
Long. Welds (Unirrad.)	$1.07 \times 10^{-10}$	$1.07 \times 10^{-10}$	$5.01 \times 10^{-6}$	$5.01 \times 10^{-6}$
Circ. Welds (All)	$1.26 \times 10^{-40}$	$1.10 \times 10^{-40}$	$1.94 \times 10^{-22}$	$2.12 \times 10^{-22}$
Totals	$5.69 \times 10^{-8}$	$5.69 \times 10^{-8}$	$6.46 \times 10^{-6}$	$6.46 \times 10^{-6}$

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**