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NUCLEAR REGULATORY COMMISSION

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MEETING

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

MATERIALS AND METALLURGY SUBCOMMITTEE

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TUESDAY,

APRIL 15, 1997

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 1:00 p.m., William J. Shack, Chairman, presiding.

MEMBERS PRESENT:

WILLIAM J. SHACK Chairman

THOMAS S. KRESS Member

ROBERT L. SEALE Member

ACRS STAFF PRESENT:

NEAL DUDLEY

ALSO PRESENT:

STEPHANIE COFFIN

KURT COZENS

ROBERT HERMAN

JOE MUSCARA

JACK STROSNIDER

TED SULLIVAN

A-G-E-N-D-A

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

(1:09 p.m.)

CHAIRMAN SHACK: The meeting will now come to order. This is the first day of the meeting of the ACRS Subcommittee on Materials and Metallurgy. I am Bill Shack, Chairman of the Subcommittee.

I have a conflict of interest with some of the topics of today's meeting. During the discussion of those topics, Dr. Robert Seale will serve as Chairman.

The ACRS members in attendance today are Tom Kress and Bob Seale. The purpose of this meeting is to hold discussions with representatives of the NRC Staff and Consumers Power Company concerning generic letters associated with steam generator tube inspection techniques, effective use of ultrasonic testing techniques and in-service inspection programs, degradation of steam generator internals and degradation of pressure vessel head penetrations.

We will also discuss the status of issues related to pressure vessel integrity. The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions, as appropriate, for deliberation by the full Committee.

Noel Dudley is the Cognizant ACRS Staff Engineer for this meeting.

The rules for participation in today's meeting have been announced as part of the notice previously published in the Federal Register on April 4, 1997.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register Notice. It is requested that speakers first identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

We have received no written comments or requests for time to make oral statements from members of the public.

We will proceed with the meeting and I'd like to call on Jack Strosnider who has some comments he would like to make before we proceed with the first formal presentation.

MR. STROSNIDER: Is the microphone working? How's that? Okay. Good afternoon, my name is Jack Strosnider. I'm Chief of the Materials and Chemical Engineering Branch.

I just wanted to briefly make a few opening remarks. And the first thing I thought might be useful was just let you take a look at the organizational chart for the Materials and Chemical Engineering Branch in the Office of Nuclear Reactor Regulation. This is the branch that I'm Chief of.

We have roughly 26 or 27 people at any given time following materials issues primarily in operating our reactors.

We have the names of the individuals here. We have two sections, and you can see some of the major areas of responsibility within the branch.

We don't have the lead on all of these, but most of them we do. And they are some of the larger issues.

Some of the acronyms here, you know, reactor pressure vessels, including all the vessel integrity analysis, control rod drive mechanism, penetration cracking, BWR internals, cracking the Core shroud issues, core spray piping, things of that nature, BWR pipe cracking, any flaw evaluations that come out of in-service inspections, leak before break evaluations, reactant coolant pump fly-wheel evaluations. That has to do with the inspection intervals on fly-wheels, and a large number of issues related to license renewal.

We don't have the lead on those issues. There's a special group that does that. But we do a lot of the technical review of license renewal issues.

It's Section A, a very clever title. This is Section B where we deal -- they call this the "steam generator section," which really isn't completely fair,

although that is a large piece of work for that section and for the branch.

But they also get into issues involving other water chemistry, post-accident sampling systems, decon, fuel oil, hazardous materials, coding, list of other issues there, and some other inspection areas such as Appendix VIII: performance, demonstration, initiative.

So, I just thought it might be helpful for you to see the types of issues that are being dealt with in the branch, and have some names for who's doing it.

Now actually looking at today's agenda, I think you've got a pretty good cross-section of some of the work that's going on. These are some of the more important subjects you're going to hear about.

And you're going to hear from the people who are doing this, doing a lot of this work So, you're going to hear from the staff today. It's the first time that some of them have had a chance to talk to you, so you'll have -- be able to associate a face with the names.

The other thing, of course, to recognize is that this agenda includes presentations from the Office of Research, from Mike Mayfield's branch. And I would just like -- I think that we have pretty good coordination with that group, something that we rather pride ourselves on, that we work very closely together.

We've had staff members work in both those branches. And so, you'll be hearing from some of the staff members.

CHAIRMAN SHACK: You pass and back and forth, it looks like.

MR. STROSNIDER: Yes, well, that happens. So, I just wanted to give that brief introduction of how the branch is structured.

Obviously, we're not structured by discipline. We're structured more by issue.

Previously, we had been somewhat more along a discipline issue. But in going into two sections, that was pretty hard to do.

So, we have a pretty wide spectrum of talent in each of these sections going all the way from, you know, corrosion and metallurgy and materials expertise up through fracture mechanics, component integrity analysis, those sort of things.

So, that's basically just a brief introduction I wanted to give. I don't know if you have any questions on that. If not, I'll turn it over to Stephanie Coffin. She's going to talk about a generic letter on degradation of steam generator internals.

MEMBER KRESS: Is there any significance to the order of the names?

MR. STROSNIDER: Excuse me?

MEMBER KRESS: Is there any significance to the order of the names?

MR. STROSNIDER: No, they're just alphabetical, and they're not meant to line up with the issues necessarily.

MEMBER KRESS: They're not really alphabetical either, and that's why I wondered.

MR. STROSNIDER: Really? There was an attempt at one point in time -- as people have come along and been added, they might not have gotten in.

MEMBER KRESS: But I can't draw lines across?

MR. STROSNIDER: No, that's the important point.

MEMBER KRESS: All right.

MR. STROSNIDER: You can't draw the line straight across to the issue, but at least you know which section it's in.

CHAIRMAN SHACK: Now, does your branch get most of the NDE resolution -- you know when somebody finds a crack, the inspection and it's a difficult problem to resolve --

MR. STROSNIDER: Yes.

CHAIRMAN SHACK: -- does that end up back with you guys?

MR. STROSNIDER: The flaw evaluation ends up in our branch. And that's -- we had, up until I guess six or nine months ago, lead responsibility for all the in-service inspection program reviews.

But in an effort to redistribute and equalize some of the workload, the Structural and Geosciences Branch is actually doing the reviews of the in-service inspection programs at this point in time.

They also have the lead on development of risk-informed ISI. And we're working very closely with hem on all those areas.

But there were some resources over there that could be used, and it was just a matter of --

CHAIRMAN SHACK: What NDE inspection issues do you deal with then now?

MR. STROSNIDER: We're dealing with largely --

CHAIRMAN SHACK: Steam generator stuff or --

MR. STROSNIDER: Yes, what we try to deal with here is anything that deals with any policy-setting type issues, basically the routine program reviews. You know, we don't feel we have to get deeply involved in it.

But when we get to Appendix VIII, for example, which you're going to hear about later today, we're involved in that, and certainly any of the flaw evaluations.

If people find defects in-service, then we do the review if it requires an NRC evaluation.

Some of the other inspection areas might include, for example, qualification of the NDE methods for BWR internals. The industry has submitted a number of different topical reports on the scope of inspection, methods of inspection for internals.

And we have the lead on reviewing that because that's sort of a new area.

MEMBER SEALE: I can see you're going to have a lot of problems which are going to be scattered across this. Certainly corrosion and BWR pipe cracking probably has something in common, and things like that. Do you just put together task groups between the two and that's the way you go at it?

MR. STROSNIDER: When it's necessary. I don't know if I mentioned this: this structure has only been in place for about a month now. So, we're still learning as we go along.

We had three sections. But in part of adjusting our supervisor to staff ratios and those sort of moves, we've gone to two sections now.

So, some of that we're still working out. Like I said, we've got a mix over here. In some cases where you look at issues like BWR pipe cracking, you know,

we have people in this section who have understanding of corrosion and fracture mechanics and the things you need to do.

And to some extent when you start looking at BWR internals, steam generators, you're going to have similar issues with regard to non-destructive examination, growth rates, fracture mechanics analysis.

So, there's a sprinkling in both sections of the expertise. We tried to spread it out a little bit. If we need to borrow between sections, then we do do that.

And that happens occasionally. And we're learning with this new structure, we've got to move some issues around.

MEMBER KRESS: Do you guys fund the heavy section steel program or is that in Research?

MR. STROSNIDER: No, that's in the Research Office.

MEMBER KRESS: But you guys write the user need letter for it?

MR. STROSNIDER: Yes, we have supported that with user need letters, and there are periodic reviews. We get together. In fact, we're going to be meeting later this week in our Research Staff to discuss that and some of the other research programs.

MEMBER SEALE: Jack, just one little bit of

advice: when you find out that you've got all of your issues sorted out to the point where you can either pack them into one section or the other, then it's time to reorganize again because you're letter the organization rather than the problem drive your solution.

MR. STROSNIDER: Good point. Well, when we get to that -- okay? Thank you. Stephanie?

MS. COFFIN: Now, Jack already introduced me. My name is Stephanie Coffin. I'm an Engineer in the In-service Inspection Branch, a section of the Materials and Chemical Engineering Branch.

The generic letter degradation of steam generator drills was issued for public comment at the end of December of last year. And it followed up Information Notices 96-09 and 96-09 Supplement I, which described damage to steam generator internals at several French PWR facilities.

The EDF experience is significant and possibly applicable to the US PWRs, and the generic letter requests how addressees responded to the EDF findings.

There are several degradation mechanisms discussed in the generic letter. In April of 1995, anomalous tube support plate eddy current signals were noted during routine in-service inspection of steam generator tubes at one French PWR facility.

They followed up those signals with a visual inspection and confirmed wastage of the uppermost tube support plate. And EDF, the utility, determined that the wastage was the result of misapplication of a chemical cleaning process.

They then reviewed eddy current signals at other facilities and found more anomalous eddy current signals, and followed those up visual inspections and found at eight facilities cracked tube support plates near the radial seismic stop and the inside rotation key.

And these signals, they traced them back -- the eddy current signals, traced them back to the pre-service inspection data and from -- mostly from that information and their visual inspections, they believe that the cracking occurred during the final heat treatment of the steam generators.

They have also found at four facilities wastage of the tube support plates at various elevations through the steam generator. And this is of particular concern because it appears to be an active degradation mechanism and that the eddy current signals are changing over time.

MEMBER KRESS: The plates are perpendicular to the tubes.

MS. COFFIN: That's right.

MEMBER KRESS: Where does this wastage show up then?

MS. COFFIN: It's mostly -- well, for the chemical cleaning one, it was -- I'm not sure if it was on the periphery or if it was in the center of the plate. But it turned out that it was directly underneath where a hose for the chemical cleaning was directed.

MEMBER KRESS: It had been directed.

MS. COFFIN: And it was obviously impingement from that chemical cleaning process. I think the wastage in the third bullet is -- I'm not sure if that's distributed randomly or if that's near a periphery too.

And lastly at one PWR facility, they experienced tube bundle wrapper drop. In one of their steam generators, the wrapper dropped 20 millimeters. In another steam generator, it dropped five millimeters, and they found that the support walls were broken.

And EDF blames poor quality welds and severe cooling transient for the broken support welds that led to the wrapper drop.

MEMBER SHACK: What were the circumstances that led to that large injection of the auxiliary fuel feedwater?

MS. COFFIN: I can get back to you on that one. I have the background information, but it was --

apparently according to EDF, it's just sort of this one facility that did this strange cooling transient. But I have the information on that.

Maybe we can go through this, and I'll go look that up.

MR. SULLIVAN: My name is Ted Sullivan and I might be able to add a little bit. I think this only occurred at the facility called Bligh 2. And it had to do with the way they were shutting down the reactor and using auxiliary feedwater to try to rapidly get the plant cooled down.

I can't say like Stephanie that I completely understand the theory. But it does have to do with some procedural controls that the Licensee had over use of feedwater to shut the plant down.

They were, as far as I know, unique to that facility, and they're not being used at that facility anymore.

MEMBER SHACK: Okay, but I mean it was a deliberate procedure then?

MR. SULLIVAN: Yes.

MS. COFFIN: The foreign expanse is safety significant in that the steam generator tube integrity could be compromised if the tube support plates are damaged or degraded or if the bundle wrapper drops.

For the damage to the tube support plates, the wastage and the cracking, EDF screens for tube support plate damage using eddy current. And whenever possible, they'll follow up any anomalous eddy current signals with visual inspections.

And tubes that are found to be without lateral -- adequate lateral support are removed from service.

For the bundle wrapper drop, EDF confirmed acceptable wrapper welds at other facilities through visual inspections. And the steam generators at the one affected facility, repairs have been completed.

In the U.S., damaged tube support plates have been associated with severe denting. And this was an active degradation mechanism over 15 years ago, and is now considered to be under control. However, the EDF experience indicates that there may be other mechanisms out there that can cause tube support plate damage.

What little we do know, the U.S. experience related to the EDF findings is pretty limited. But Diablo Canyon in the spring will be visually inspecting their tube support plates corresponding to some anomalous eddy current signals that they detected. And that's this spring outage.

And we also know that Byron and Braidwood, in support of a three volt alternate repair criteria

amendment, did extensive visual and eddy current inspections of those steam generator internals and did not find any degradation.

The EDF experience may be directly applicable to U.S. facilities, and particularly the active wastage mechanism that I mentioned earlier, and maybe the cracked tube support plates and the bundle wrapper drop.

PWR licensees need to show how Criterion XI, "Test Control," and Criterion XVI, "Corrective Action," are being met. These are from 10 C.F.R. 50, Appendix B in their response to the generic letter.

Specifically, the generic letter requests essentially one of three things: it will describe for us the program you have in place for detecting steam generator internal degradation, or describe your plans for developing such a program, or else tell us why you don't think such a program is needed.

MEMBER SHACK: What's the philosophy being this kind of generic letter where it looks like you're just sort of asking for information? Doesn't this come out of your normal inspection programs whether people are, you know, adequately treating this kind of a problem?

MS. COFFIN: Not really.

MR. SULLIVAN: The normal inspection programs -- this is Ted Sullivan again -- focus on the tubes. And

there aren't any explicits in code or tech spec requirements that would direct a licensee to examine the internals.

MEMBER SHACK: Okay. So in essence then, we're -- so, you're not asking them to implement such a program. You're only asking whether such a program exists at the moment?

MS. COFFIN: That's right.

MR. SULLIVAN: We're asking and we're pointing out the regulatory requirement that we think underpins this type of request.

MEMBER KRESS: Did you issue an information notice first?

MS. COFFIN: Yes, 96-09 and a supplement to that too.

MEMBER KRESS: And this followed later?

MS. COFFIN: [illegible] generic letter followed those two information notices.

MEMBER KRESS: Is this still out for public comment or is it --

MS. COFFIN: No, public comment expired on March 15th. And I'll go over to the significant comments that I got.

MEMBER KRESS: Okay.

MS. COFFIN: The first comment was from

NUBARG, which is the Nuclear Utility Backfitting and Reform Group. And they state in their comment that, "The generic letter implies that licensees should be performing inspections of their steam generator internals."

And they suggest that the Staff perform a backfit analysis.

Our response to this comment is firstly, right now, the generic letter is only asking for information. No action is required in the response to the generic letter.

And secondly, the Staff considers the Appendix B Criteria XI and XVI apply in this situation, and we request information from the licensees to see how they comply with these criteria.

And there's no new or revised Staff positions or requirements.

MEMBER KRESS: I have never heard of NUBARG. Are they just an independent of NEI or --

MS. COFFIN: I've never heard of them either. So -- a lawyer group wrote for them. I really don't --

MEMBER KRESS: Did they formulate that group just because --

MS. COFFIN: Maybe.

ACTING CHAIRMAN SEALE: Would you give us that acronym again?

MS. COFFIN: NUBARG, Nuclear Utility Backfitting and Reform Group.

ACTING CHAIRMAN SEALE: It's not even plain whether or not the members are nuclear utilities, is it?

MR. COZENS: This Kurt Cozens from NEI. I can address your question about NUBARG. NUBARG is a separate group from NEI. It has existed since the 50.109 regulation was promulgated.

And they have a fixed membership comprised of nuclear utilities.

MEMBER KRESS: Thank you very much.

ACTING CHAIRMAN SEALE: Thank you very much.

MS. COFFIN: The second significant comment was from NEI, Nuclear Energy Institute. And again, they comment that the generic letter imposes actions on the licensees to perform inspections.

And again, our response is that right now, we're just requesting information.

And secondly, they made a point that the industry is forming a task force to address our issues that we brought up in the generic letter, and that no generic letter is needed.

And our response to that is it's important that the Staff document their position on the French findings and the generic letter and our concerns with

Appendix B criteria being met in this regard. And the generic letter is a good vehicle for us to document that, and also to document how licensees respond.

So regardless of what industry task force forms, we still see a need for the generic letter.

And I'm currently addressing comments for the final generic letter publication. And in response to the generic letter, we expect most licensees -- most addressees are going to reference an industry document prepared and coordinated with their NSSS vendors and NEI and perhaps EPRI. And are there any questions or comments?

ACTING CHAIRMAN SEALE: Well, it is true that a lot of utilities have, in fact, inspected the internals on their steam generators, or at least some have.

MS. COFFIN: Documented results I've seen for Byron and Braidwood.

ACTING CHAIRMAN SEALE: And I think there was something on Palo Verde's internals inspection when they had that axial rupture too, something like --

MR. STROSNIDER: This is Jack Strosnider and yes, we have been informed, I think, in various meetings with the industry that people have performed inspections.

When we were doing the Byron/Braidwood review, there was some discussion that inspections were done in

other units.

But the extent of those to scope, the methods, the controls of them, are something that we really don't have a good handle on. And that's --

ACTING CHAIRMAN SEALE: And that's what you're trying to do here?

MR. STROSNIDER: Yes, that's exactly one of the reasons for this type of letter. You know, part of the response here, if licensees have done inspections, is they could come back and tell us, "We've done inspections," and what areas they've looked at and why they think what they've done is adequate.

Some of the comments -- and I think this is an interesting example because this type of letter -- these comments come up frequently: "The letter implies that we need to go take some action," all right?

What we're doing is we're saying, "We have a regulatory requirement, all right, to make sure, you know in Appendix B here, that you're doing proper examinations, dispositioning any findings, to make sure that the safety related components are able to perform their function."

If you can respond to the letter by saying, "We don't need to do an inspection because," or "We've done some inspection," and it addresses the issue, that's fine.

If, in order to satisfy the regulatory requirement, you conclude that you need to go do -- take some action and do some inspections, well, that's not a result of this letter. The requirement was already there, and you needed to be doing it anyway, particularly in the face of evidence that says there may be a potential for degradation. It's hard -- it's hard to ignore.

So, we see this comment a lot. We put out letters where we are requesting information because we don't know fully what the industry has done or, you know, if there may be some other technical basis for saying it's not important to go inspect. This is an opportunity for people to tell us that.

The same token: if, in order to comply with the regulations, they need to take some additional action, then that's the action they need to take.

ACTING CHAIRMAN SEALE: This may be asking after the horse has gone and the barn door has now been closed as of the 15th of March or whenever it was, but in the request for information where people informed you that they, in fact, have already done some inspections, have you asked them to also tell you why they did the inspection? It seems to me that's --

MR. STROSNIDER: No.

ACTING CHAIRMAN SEALE: No?

MR. STROSNIDER: I don't think we specifically requested that from them.

ACTING CHAIRMAN SEALE: You know, but it seems to me that's exactly the kind of information that other utilities might want to be on the look-out for. That is, if there was a symptom that showed up that convinced someone that they needed to look at the internals, then if someone --

MEMBER SHACK: Beyond an information notice.

ACTING CHAIRMAN SEALE: Yes, I'm saying where people have already done it because they had a problem. In a sense, that may or may not be a valid diagnostic for other people to warn them that they might have a problem. And that may be the thing they need to be looking for.

MR. STROSNIDER: Yes, I understand your point. We did not specifically --

ACTING CHAIRMAN SEALE: I understand, yes.

MR. STROSNIDER: -- ask for the reason people did inspections. They may or may not provide us that information.

ACTING CHAIRMAN SEALE: Yes.

MR. STROSNIDER: We certainly -- if we see something reported in these responses that we think is important, we can always talk to that licensee and get some more detail.

ACTING CHAIRMAN SEALE: Sure, yes.

MR. STROSNIDER: And one of the things we've been trying to do with all these generic letters is document our close-out of these letters and not just by sending the letters to the licensee. But we have issued in the past some NUREG reports, and it is our plan with these to do something similar to that so that we can try to take an integrated look at the responses and determine if any additional notification of the industry or anything else is appropriate.

MEMBER KRESS: Jack, what happens if you get a response from somebody like along the lines -- "We have never inspected this part of our steam generators because we just didn't think there was any problem. But in view of this experience, foreign experience, we plan to do the inspections from now on?" Would they be considered out of compliance with that kind of reply? And would you guys have any problem with that?

MR. STROSNIDER: No, I -- my gut reaction is that no, we're not going to find people out of compliance because they haven't previously been doing inspections. But I think, you know, when you become aware of degradation that's going on, you need to consider its applicability to your facility.

And I think the regulations are clear in

looking at that.

MEMBER KRESS: Yes.

MR. STROSNIDER: And if you do that and you decide what actions are appropriate, then we asses those. But I don't see looking in hindsight at this and saying, "We should have been inspecting this all along."

MEMBER KRESS: Okay, thank you.

ACTING CHAIRMAN SEALE: Forgiveness is easier than permission.

MR. STROSNIDER: Just one other comment, and that's all, and it's just reminding that one of the things that we did request in the letter is that if people have previously done inspections and identified degradation, that they tell us how that degradation was assessed, the disposition.

So, we should -- I mean, one of our intents was to find out if there was something out there that we're not aware of, and if people know about that, to share that information with the rest of the industry.

ACTING CHAIRMAN SEALE: Is that all that you had, Ms. Coffin?

MS. COFFIN: Yes.

ACTING CHAIRMAN SEALE: Thank you very much. We appreciate your presentation. Who's next, Jack?

MR. STROSNIDER: I guess now we're going to

move into the --

ACTING CHAIRMAN SEALE: Are you back on the saddle now?

CHAIRMAN SHACK: Well, since he's my Program Manager --

ACTING CHAIRMAN SEALE: No, okay, I guess you're not.

(Laughter.)

CHAIRMAN SHACK: I think I'm slightly conflicted again.

MR. STROSNIDER: The next issue we're going to discuss is, I think, performance based qualification and non-destructive testing methods.

ACTING CHAIRMAN SEALE: Okay.

MR. STROSNIDER: And this deals with Appendix VIII of the Code, "Performs Demonstration Initiative by the Industry." And Dr. Muscara from the Office of Research has been involved in this area for a long time. I think he's prepared to give a historical perspective on the importance of this area.

We'll follow that up with a discussion on the generic letter that we've developed in this area.

DR. MUSCARA: Good afternoon. I'm Joe Muscara. I'm with the Office of Nuclear Regulatory Research. And this afternoon, I would like to discuss

with you some of the background on NDE reliability that's in support of performance demonstration.

Much of the work on inspection reliability has been conducted under one research program that was initiated at the Pacific Northwest Laboratory in the Fiscal Year 1977.

As I mentioned, I will only cover a _ry, very small fraction of the results of that work and some results from other programs also.

But this project has always had three major objectives. The first objective was to determine and quantify the reliability of ultrasonic in-service inspection that is conducted on commercialized water reactors, in particular for piping and for pressure vessels.

We then wanted to recommend Code changes that would improve the reliability of such inspections. And as a final step to our program, we wanted to develop a basis for the inspection program and that is based on the importance of the component to safety and the material properties and service and NDE certainties to formulate the inspection program with respect to frequency of inspection, what to inspect, how reliably to inspect, to achieve suitably low failure probabilities commensurate with the safety function of the component.

And I will not talk about that work at all. But in effect, what we're talking about here is there is base inspection guidelines that are being developed right now. We began working on that in 1987 at PNL.

And in 1989, we also funded a research grant with the ASME Research Task Division.

As a way to indicate a little bit of background for this program, we first had a need to evaluate any reliability in a study that the Office was conducting in evaluating the cold break probability.

We wanted to see whether the probability cold break, cold leg break, was low enough to essentially not consider it as a design basis accident.

We were also, of course, concerned about the quality and the frequency of the inspections that were being conducted, and particularly in view of the pipe cracking experiences we were having in the early to mid and late 70's.

Also, the PDRC work conducted between 1965 and '75 and PISC 1, which was conducted between '75 and '80, had identified poor reliability for inspecting heavy section steel and pressure vessel steels.

With that background in mind, we wanted to make improvements to the Code as quickly as possible. So, our first work had to do with doing some parametric

studies, to evaluate important inspection parameters on the reliability inspection, or at least on the -- on the signals that were produced from the ultrasonic inspection.

And we looked at many, many variables and we performed 6,000 measurements in that study. Those results were used to develop recommendations for improved procedures, and these were incorporated in Research Information Letter No. 113 that was issued in 1981.

And in 1982, the recommendations were placed into the ASME Code Case N-335.

Following the parametric studies, we conducted two round-robin inspections to quantify the POD as a function of crack size, false call rate and sizing accuracy.

The first of these studies was the piping inspection round robin conducted in 1982. Six commercial ISI teams participated in this project. Each team was made up of three persons from a particular company with varying amounts of experience and including Levels I, II, and III Inspectors.

That particular work, where we conducted 1,500 measurements, under typical, realistic conditions. We followed up that particular work with what we called the mini-round robin, and this concentrated on stainless steel pipe cracking, IGSCC.

And in this testing, we looked at 12 individuals and three inspection teams that used automatic equipment.

In the piping inspection round robin, we looked at the major piping materials that are used on light water reactors. We looked at clad ferritic piping, 32 inches in diameter, 2 3/8 inch wall thickness.

Within this material, we had 16 thermal fatigue cracks that range in length from 1.25 to 3.1 inches, and in depth from 0.3 to 1.1 inches.

We evaluated the centrifugally cast stainless steel piping material, and this was at 33 inch piping sections, 2 3/8 wall thickness.

These samples contained 19 thermal fatigue cracks, again ranging in lengths from 1 to 4 inches, and in depth from 0.3 to 1.25 inches.

And we also evaluated wrought stainless steel. This material, we looked at 10 inch diameter piping in Schedule 80 in ADS. So, we had 0.5 or 0.6 inch wall thickness.

Within this material, we had 23 intergranular stress corrosion cracks and 28 thermal fatigue cracks. Lengths ranged from 0.16 to 2.3 inches for the IGSCC, and 0.33 inches to 2.4 inches for the thermal fatigue. And the depths ranged from 0.1 to about 0.3 inches.

In the mini-round robin, we have evaluated wrought stainless steel in 10 and 12 inch diameter in various schedules, Schedule 80 and Schedule 100. So, we had thicknesses from 0.6 to 0.85 inches.

And we looked at a total number of 28 intergranular stress corrosion cracks. Flaw lengths varied from less than 1 inch to 40 inches. So, some of these had cracking all the way around the pipe, and a flaw depth rate from 0.03 to 0.45 inches.

Now, I'd briefly like to go into some of the results. I'm only going to show you this one viewfoil from the 6,000 parametric studies. But here we are looking at the effect of the transducer size on those responses from different types and sizes and angles of flaws.

And this information essentially was used to determine an appropriate transducer size with respect to the piping thickness.

And this kind of information, as I mentioned before, has gone into the ASME Code. The kinds of recommendations that were incorporated into the Code from this work were the transducer size to be used, the inspection angles.

We effectively recommended the addition of a 60 degree angle; the scale overlap, where we recommended a

50 percent overlap; and other parameters that had to do with the dynamic of the transducer.

Also in this particular recommendation, we, for the first time -- so back in 1981, we recommended that performance demonstrations should be conducted for stainless steel piping and for the similar metal welds.

This is one of the early plots from the piping round robin work. And it effectively shows the relative capability for ferritic piping, cast stainless steel piping and wrought stainless steel piping.

As we can see, the ferritic piping inspection was fairly reasonable. We have fairly good capability.

The stainless steel piping with IGSCC has somewhat of an intermediate level of capability. And the cast stainless steel pipe is essentially totally uninspectable.

We have -- their probability of detection is around 20 percent an the false call rates were quite high.

Well, that was one interesting plot that essentially made the case of the relative performance of the materials. But in looking more carefully at this information, we noticea besides the relative level of capability that there's a great deal of scatter in the performance of various things with various flaws; in particular, for the stainless steel with IGSCC.

Again, we can see that for the cast stainless steel, there is very poor inspectability. There are two datapoints that are 100 percent inspection.

I guess I should mention that in this material, there is no lack of signals. It is quite noisy material, and the same as the wrought stainless steel with the IGSCC.

The problem is really to distinguish geometric reflectors or grain boundary reflections from cracking.

And what happened in the case here of these two datapoints at 100 percent POD is that the inspector was calling everything cracked. So if you call everything cracked, he gets all the cracks, but he also has a tremendous amount of falls calls.

So, we learned in our work later on to have penalties for false calling.

An additional bit of information from the piping inspection round robin was there is a comparison here of the inspectability of wrought stainless steel from the near side and from the far side.

Inspection from the near side, essentially the flaw is on the same side of the transducer beam -- as the transducer beam. So, the beam does not have to cross the weld metal.

And the inspection reliability is fairly

reasonable. This is the top curve for the near side.

For the far side, the beam has to traverse the weld metal. And here, we essentially have a cast structure.

And so, the inspectability of a dissimilar metal weld or going through the weld for a wrought stainless steel is quite poor.

This plot shows performance of the six teams that participated in the round robin inspection. We notice that the average for the far side again is quite poor, the average for the near side, intermediate.

There were two teams that performed reasonably well, and three teams out of the six that performed quite poorly.

So, there is quite a range in performance from team to team, essentially using the same kinds of procedures and equipment.

This data is from the mini-round robin where we --

MEMBER SHACK: Joe, does the Code essentially tell you -- I mean, you do the near side inspection when you can. You do the far side inspection only when you have to.

DR. MUSCARA: Yes, the Code requires inspection from both sides if you can -- if you can get

access to both sides. So quite often from piping to component, you only have access from the piping side. And if the flaw happens to be on the other side of the weld, it is really uninspectable.

We show similar results here for the mini-round robin. I should mention the mini-round robin was conducted after the I&E 83-02 Bulletin that required some sort of a performance demonstration for stainless steel piping, and was conducted at the NDE Center.

So, the teams that participated in this round robin had passed the NDE Center test, both the sizing and detection test.

And what we found was that the performance was quite similar to what we had determined from the prior testing a few years earlier.

The experience at the NDE Center had been that only about 40 percent of the teams passed those tests on the first try. And that was true both before and after this mini-round robin.

So, the inspection of POD versus flaw size is quite similar. And here, we are showing the relationship between the probability detection and the false call rate.

Again, we see that two or three teams perform acceptably well, the other three teams fairly poorly. When I say that these teams performed reasonably well, we

have defined an acceptable team as a team that has a probability detection of 80 percent with a false call rate of less than 20 percent.

And we do have three teams that fell -- that met that category.

But again I'd like to stress that regardless what the capability is, there's a lot of variability from team to team performance.

And this viewgraph essentially is from the data I've just shown you for the different teams, the 15 different teams, that participated in the mini-round robin. And we're showing the upper and lower 90 percent confidence, both for the false call probability and for the probability detection.

You'll notice on this first table, for example, there are only three teams there who met the 80 percent POD with less than 20 percent false call.

But notice the large ranges in variability between the upper and lower 90 percent.

So effectively, we were trying to make the point that even though the capability can be improved, the inspector plays a major role in the final outcome and that we need to have performance demonstration to screen poor inspectors.

ACTING CHAIRMAN SEALE: Has there been any

effort -- I know in the steam generator tube inspection area, there's been work on developing software to help interpret results. Is this kind of -- would it be amenable to a similar approach?

DR. MUSCARA: Yes. In fact, my personal view is that the ultrasonic field is much farther ahead than the eddy current in applying signals.

ACTING CHAIRMAN SEALE: Now, is that -- what's the performance of that when you superimpose all this?

DR. MUSCARA: I will have some data later on that shows some of the more advanced techniques. But in effect, the inspector plays a really major role. It's a skill --

ACTING CHAIRMAN SEALE: Clearly.

DR. MUSCARA: -- dependent technology. And even when we improve the capability by conducting various signal analysis procedures and using the physics of the inspection to determine flaw depth and flaw length, we still find that there is a large amount of variability.

Well, this viewfoil is just to introduce a little bit of information or data from the PISC inspections. Now, the PISC is an international program that the U.S. has participated in.

We, in fact, have provided many samples and inspection teams for this work. And this shows the

capability that was determined in the mid to late 80's for a stainless steel piping. And in effect, it's similar to what we have found in the earlier 80's.

MEMBER SHACK: But, I mean, these are European teams. Would they have been using the same techniques? Would they -- they wouldn't have been through the EPRI qualifications.

DR. MUSCARA: Yes, they -- many of these techniques are quite similar. Part of the problem is that most of these are amplitude-dependent; not all, but many of them.

I'm not showing you the information now, but we provided samples to PISC and also participated in what we call the UT reliability round robin, which followed the information I'm showing you now. That information is being evaluated right now.

So, we did have U.S. teams participating along with European, Japanese, and Russian teams.

From evaluating work from the past and on the vessel inspections, the U.S. teams performed very similarly to the European teams given similar procedures.

Right, this is one that I just discussed. Now up to this point, I've talked about essentially the probability flaw detection or the reliability of the detection process in piping materials.

We also evaluated the sizing accuracy, of various techniques that are applied for inspections as required by the Code.

Many of these techniques have been based on amplitude drop, and they have severe drawbacks. What you notice here is that there is really actually very little, if any, sizing capability.

I am showing information here on the sizing capability for ferritic piping. The reason I chose this example is that in ferritic piping, as you notice, the probability detection was reasonably good.

But the sizing is an entirely different story. So even though the material is clean and there is very little to worry about with respect to evaluating signals, whether they're from flaws or not from flaws, when it comes to sizing and using amplitude drop techniques, even with good clean signals, the sizing is not acceptable with amplitude drop techniques.

MEMPER SHACK: So, this is all amplitude drop and no --

DR. MUSCARA: Yes, this is all Code procedures, yes. This is showing the mini-round robin sizing results. And here -- now, the teams have gone through the EPRI NDE Center qualification.

And we notice that the -- at least for the

best team, he has an improved sizing capability. It's really a lot better than the worst team. And in most cases, these worst teams have absolutely no slope, about zero capability for sizing.

But what's not shown here for the specific team is that there's still a lot of variability in the sizing performance. And often, the -- I guess which is also a bit of a problem, the large deep flaws would tend -- tended to be under-sized.

MEMBER SHACK: Now again, what would be the technique they were using for these?

DR. MUSCARA: Here, they've used a number of different techniques that are a part of the EPRI NDE Center protocol. So, they have moved their way, in these studies, from the strictly amplitude-based techniques.

Some of the techniques use crack tip to fracture to do the sizing. But of course, the problem with that is that you have to identify the proper crack tip.

And now the results on sizing from the PISC III work, which was conducted later. And again, we see there has been an improvement in the correlation, but there's still a great amount of scatter.

So, it's operator-to-operator dependent, even with the better techniques.

Right, so that covered essentially detection and sizing in piping materials. I'd like to address a little bit the capability for inspecting pressure vessel steels.

In this viewfoil it shows data that was generated by PISC I. Now, PISC I was conducted actually on some American blocks. These were PVRC blocks.

Now, PVRC had found that the inspection capability for pressure vessel material was quite poor. The Europeans felt they could do much better. They asked for these blocks. They were sent to Europe, and they conducted the PISC I exercise.

And their performance was just as poor as it had been in the States. Again at that time, they were using amplitude based techniques, and they're just not quite acceptable for detection or sizing.

What we see here in this Zone 1, those are flaws that are said to be acceptable. This is by ASME acceptance tables. In the next area, we have flaws that are not acceptable. These are vertical crack-type flaws. And you can see probability detecting even a one or two inch flaw can be down below 50 percent.

In this third zone, we were looking at clustering of flaws, and that made the inspection even more difficult. And the probability of detecting those

flaws is mostly below 50 percent, even if the clustered zones are of the order of four or five or six inches.

Now, we have made use of some of the work from PISC in updating the Code. And some of that update was taken from data such as the one I'm showing you now where we are looking at the relative capability of the inspection of pressure vessel steel using the ASME techniques, but at different sensitivity thresholds.

So if using 50 percent, that procedure which was the Code back in the 70's and 80's, probability detection is quite, quite low. And we also show a large variability in the probability detection values.

At 20 percent, we have an improved capability for detecting flaws. But again, the two standard deviations there show a large variability in the inspection results.

The dashed line was the Marshall Committee. POD is a function of flaw size that was desired. And what we show here, the top line, is what's called "Special Procedures (European)," and these were mostly -- type defraction techniques and ALOK and in-line SAFT.

They're called "European" because the U.S. didn't participate in that particular round robin. But in fact, the SAFT technology did come from the U.S.

And what was being used in Europe was a line

SAFT instead of a volumetric SAFT, which was not quite as capable as the volumetric SAFT.

So for the special procedures, there is an improvement.

Now, and this is the kind of information we see published in the PISC reports. And what I wanted to show you is when we take that data and reduce it down and at least show the individual datapoints, what we are looking at here is the 50 percent DAC information.

We notice that about one-half of those flaws were totally undetected by any team. And these are flaws that ranged up to 80 millimeters.

About one-third of the flaws were detected by about a third of the teams. And the rest of the flaws, only a few teams detected.

So what's important here is that even very large flaws go undetected, and that the general capability is quite low, as was shown on the previous curve for the 50 percent DAC.

Based on the information from 50 percent DAC and 20 percent DAC, the Code accepted an upgrade on the sensitivity. And the 20 percent DAC is what is in the ASME Code at this point.

Well, this is information we obtained from 10 and 20 percent DAC. What I'd like to show again is that

although all the flaws were detected, still for large -- for several flaws and for large flaws, the detection rate is quite low still, about 20 percent.

That's not much of an improvement in detecting two, three, and four-inch deep flaws at a 20 percent level. And there is still is quite a degree of variability from flaw to flaw and team to team.

So, even the 20 percent DAC, these amplitude-based techniques, may have been an improvement in the capability, a slight improvement. There's not much improvement in the variability. And in fact, there's really not much improvement in the capability either in going from 20 to 50 percent DAC.

So, the amplitude-based techniques are really not effective and performance demonstration is needed to screen out poor inspectors from good inspectors.

This essentially shows the POD versus flaw depth for this PISC II, Plate 3, which was a plate that contained a nozzle. So, the flaws were contained in the well of the nozzle to the plate.

And again, these were the special procedures. So, you can see that the general level of capability is quite higher, and there seems to be a little bit less variability in the information.

Of course, we need to keep in mind that these

special procedures were often carried out by highly trained researchers that had all kinds of time to do the testing and the analysis.

But at any rate, the capability has improved. The variability -- then we need to do a more realistic kind of study where field type inspectors participate in the testing.

And that shows the capability in the PISC III work for Action II, which was a pressure vessel inspection for sizing techniques. And these techniques were not necessarily amplitude-based. They were mostly special procedures. Again, they were SAFT, ALOK and time of flight techniques.

And we notice that there is an improvement in the capability, but still of concern is the large amount of variability and also the large amount of under-sizing that can be done on flaws that are as large as three or four inches deep.

MEMBER SHACK: Now, are these multiple team results then or --

DR. MUSCARA: In most cases, these were one research group or one inspector. Even in our piping inspection round robin where we had the team of three people, they effectively gave individual results.

There was not much change in the Code when the

team got together and discussed the results.

MEMBER SHACK: No, I meant for like that one flaw at 95 millimeters. I mean, is that six different teams: three of them under-sized it and three of them over-sized it?

DR. MUSCARA: Yes, yes. This is essentially -- these are different flaws and different teams. So, there were several flaws at 90 percent, although they perfectly line up so I think it's just one flaw. And those are the results from the different teams.

In some of these areas, it may have been more than one flaw that were looked at by several teams.

But again, I'm showing you really a very small fraction of the results that are available in this field. But these results -- the testings that was conducted in the late 70's and through the 80's and early -- the early 90's really have indicated that ASME Code procedures, the prescriptive procedures, are not capable of providing adequate reliability.

We had felt that a new approach was needed to improve this inspection reliability, and had determined that a performance demonstration program would be necessary to improve the reliability of the inspections.

So, we began working in this area back in the early 80's to develop criteria for performance

demonstration.

We have conducted two public meetings to discuss general ideas about performance demonstration and to get technical input on what might provide a good performance demonstration program. These meetings were conducted in 1983 and 1984.

In 1983, Professor Shewman from ACRS participated in working group sessions. This was about a two or three-day session where we really put down our initial thoughts on what performance demonstration should accomplish.

In 1984, we already had what we called a "draft reg guide," and we had a public meeting to present the results of this reg guide.

At that meeting, the ASME Code personnel suggested that the ASME Code should undertake development of performance demonstration requirements using as a basis the PNL/NRC document that had been developed.

Over the next five years, some 100 participants were involved in developing these Code rules. There were representatives from the industry, from the NRC. From NRC, we had Research, Headquarters and Regions.

The key concept of ASME Section XI, Appendix VII and VIII -- there were two appendices developed.

Appendix VII has to do with personnel training and qualification. And that's a prerequisite to Appendix VIII, which is the actual performance demonstration itself.

So Appendix VIII requires training and qualification. The tests are statistically based. A key concept is that the personnel, the procedures and the equipment, taken together, which we've called the NDE System, need to be qualified.

Qualifying a procedure by itself was not adequate. So, the person, the procedure and the equipment, all realistic components, is what is required to be qualified.

Well this work, over a period of five years, really culminated some major changes in the Code in that they were moved from a cookbook procedure to a performance-based procedure.

And, of course, to conduct these tests properly using large mock-ups and components is quite an undertaking, quite expensive. And the industry has undertaken to conduct these performance demonstration tests at a large investment of time and cost.

Well, some of the characteristics of the detection test is that it's a blind test. It is statistically based. It's a screening test, so we're not

trying to lock at POD here. It's a screening test to screen out the poor inspectors.

The test is designed such that a poor inspector passes only a small percentage of the time, and a good inspector should pass a large percentage of the time.

For piping, we indicated a poor inspector would be one who is probability of detection is 50 percent with a false call rate of more than 20 percent. And this inspector should pass less than one percent of the time.

And for a good inspector, whose POD would be 90 percent or greater and a false call probability of less than 20 percent, the test is set up so that he passes 85 percent of the time.

For reactor pressure vessel, similar criteria were developed. There, we define a poor inspector as one whose POD was 70 percent or less and false call probability at 20 percent or more. And his chance of passing the test should be one percent or less.

And a good inspector would be one with a 95 percent POD and a 20 percent false call probability. And again, he should be passing at least 85 percent of the time.

I would like to emphasize again that this test does not provide us with POD statistics. When we look at

the information on the number of samples that are included in these screening tests, they are fairly small batches of samples.

For the crack sizing test, the criteria here was more based on judgement and on the experience that had been gained at the NDE Center with the IGSCC round robin trials.

The passing criteria for piping on the length size was that they should be able to size the length of a flaw within plus or minus one inch. And currently, the depth sizing is less than 0.125 RMSE.

I should mention that in the initial developments of Appendix VIII, there were other requirements on the sizing. And they had to do with the slope and the standard deviation and the amount of under-sizing that was acceptable for large flaws.

I think this simplified the test some, but there may be some problems of just having an RMSE criterion with no under-sizing.

And for reactor pressure vessels, again the length sizing should be less than 0.75 inch RMSE, depth sizing a slope of 0.7, mean deviation of 0.25 inches, and a correlation coefficient of 0.7.

MEMBER SHACK: Is this supposed to be true for cast stainless steel piping too?

DR. MUSCARA: No, unfortunately Appendix VIII has a number of supplements. And Appendix VIII itself gives the general requirements for performance demonstration, and the supplements give specifics for conducting a performance demonstration for a particular component.

There is no supplement yet for cast stainless steel piping. There had been originally, and that was the same as other piping. But I think ASME Code personnel decided that the inspection of cast stainless steel was so poor, that they did not want to have a performance demonstration on that quite yet.

And so, that is something that is under development, although there is not much activity that is going on in the Code -- in developing that supplement.

But the philosophy within the Code is that any component that is required to be inspected by the Code should be done according to a qualified procedure. And of course, if there is no supplement, then they move back to the old procedures until a supplement is developed.

So, the supplements essentially contain information on the size of the specimens, the minimum number of specimens, fabrication conditions such as the crown size and the geometric conditions.

It is stressed that they should be using

realistic mock-ups with realistic flaws.

So, information on defect conditions, such as the types of flaws and the location, orientation of flaws, are given in the supplements.

In the detection specimens, the number of flaws and the flaw grading units are given again because there is a requirement for false call probability. So, we need to have grading units that are free of flaws.

And for the sizing specimens, the number of sizes and the number of flaws are given. And there is acceptance criteria for both the detection and sizing tests.

This table comes from Appendix A in the Code, and it gives the acceptance criteria for the detection test first and then piping.

In the screening test, you can get away essentially with just a five sample test, five flaws and ten unflawed grading units for false calls. A fairly typical test is an eight out of ten test where passing the test if only you missed two flaws out of ten flaws.

I guess maybe just a word on the sample set itself. Generally for these supplements, the sample set is split up in thirds.

One-third of the sample is usually between zero and 30 percent for all flaws, another third between

30 percent and 60 percent for all flaws; and the final third of the sample has flaws from 60 percent on mounting through wall.

So when you look at five or ten specimens, you can see there are only two or three specimens in each size category.

I don't plan on spending actually any time on this, but this is just the performance demonstration history, studying in the early 70's -- well, late 70's to the present time, bringing in the research results and the Code activities.

MEMBER SHACK: Are the performance demonstrations being done by industry groups and EPRI NDE or --

DR. MUSCARA: Yes, and you'll probably hear more about it in your later presentation. But there is this PDI, performance demonstration initiative, that was put in place right after the Appendix XI and VIII were produced by the Code.

And industry essentially got together to develop their qualification program.

And so they spent literally over $10 million in putting together a program with realistic mock-ups and realistic flaws to conduct these performance demonstration.

They have run a number of inspectors through the piping inspection demonstrations, and I believe they are conducting demonstrations on pressure vessel steels also.

My recollection is that finally about 100 percent of the utilities participated in the PDI program. So, they provided funds and support for the performance demonstration.

Just to summarize, the research results and round robin tests and experience since the early 70's have shown poor reliability of many prescriptive in-service inspection techniques.

And even as improvements has been made to the techniques to the Code based on experience and research results, there is still a large amount of variability in the performance from inspector to inspector, particularly because this is a -- it's a skill-based technology.

And so even if we have capable procedures, the same procedure and equipment in a different inspector's hands, perform differently.

So, we had felt there was a need for NDE system performance demonstration to screen out the poor performance from the qualified pool of NDE systems; that is, the person, the procedure and the equipment, that are use for in-service inspections of operating reactors.

My last two bullets are more of recommendation than a conclusion. You notice that a popular test could be an eight out of ten test.

That means that the inspector can miss two frauds and still pass the test. My concern is what if this inspector misses the two largest flaws. He only has two or three flaws in each size category.

So, he passes the test by identifying eight flaws out of ten and he misses two through-wall flaws. Should he really be qualified to conduct inspections?

I think this is an area for us to look in the Staff in the future to determine whether we want some other requirement in addition to the eight out of ten.

Should there be a restriction on no flaws being missed that are greater than a certain depth?

And the last bullet is similar. It talks about the sizing qualification. Here we have an RMSE value, but there's -- at this stage, there is no criteria for how much under-sizing can be acceptable for large flaws.

As we notice from the PISC work, for example from the pipe inspection round robin work, we can call flaws that are one and two and three inches deep quite small.

That should not be an acceptable condition.

So, I think those are two areas that we may need to look at a bit more carefully for future work.

And I think this really concludes my presentation. I have in your hand-out a list of three or pages of references that are reports essentially based on the NDE reliability research work that's been conducted.

And so if this wasn't enough, there is a lot more to be looked at. Are there any questions?

ACTING CHAIRMAN SEALE: Questions?

MEMBER SHACK: It makes you glad you've got ductile materials, doesn't it?

ACTING CHAIRMAN SEALE: It sure does. Thank you, I was looking for the word. Tom, did you want to make any comment?

MEMBER SHACK: Maybe it would be better to ask Bob Herman this next. I -- the BWR people basically have to do something like a performance demonstration, right, as part of 03-13?

DR. MUSCARA: Yes, only for the IGSCC pipe cracking problem. And in fact, when you look at the ASME Code Appendix VIII for piping, that's very similar to what's going on with the BWR owners group and the NRC memo of understanding where they're doing a detection and a sizing test.

The detection test started out as a four out

of five tests and moved on to an eight out of ten. And the sizing test is very similar to what I described. So, they've been doing that since the mid 80's.

MEMBER SHACK: Okay. And so, Section VIII then really expands that to --

DR. MUSCARA: Yes, Section VIII requires it for vessels, for nozzles, for bolts and a number of components. The philosophy again is that everything that is required to be inspected should be done according to a demonstrated -- unless there's no supplement in place, in which case the supplement needs to be developed.

MEMBER SHACK: So when I guy puts in 3/16 stainless steel, he just goes back to the ordinary Code?

DR. MUSCARA: No. Well, that's according to NUREG 0?-13, but not according to the Code requirements. The Code requires performance demonstration for all piping: ferritic and stainless and centrifugally cast.

It's not in place yet, but we'll be working to get that in place.

MEMBER SHACK: I guess, but the utilities are working to the '89 Code, right, or they've long --

DR. MUSCARA: That's right. In the '89 Code, we picked up Appendix VII, which was published in 1988. and Appendix VIII was published in 1990. It's an '89 addenda and we had not picked it up yet.

But there are activities in place now to pick up the Code sections through, I believe, 95. And Appendix VIII is something that we're looking at picking up as an augmented requirement; that is, picking it up reasonably soon versus in the next ten-year inspection.

And part of this presentation had to do with providing some background on the need to do that.

MR. STROSNIDER: This is Jack Strosnider. I might just make a couple of comments in response to Dr. Shack's questions.

First, as Joe Muscara indicated, since I guess the early or mid-80's, there's been an agreement between the NRC and EPRI and the industry that they will qualify inspectors looking at BWR piping for IGSCC through a performance demonstration program that was run down at the EPRI NDE Center.

About a year and a half ago, we basically amended that agreement to indicate that the industry could now use the Appendix VIII PDI, in fact, approach for qualifying people.

So, we worked out some protocol for people transitioning from the old agreement to the new agreement. So in fact, a lot of people are now actually qualifying through the PDI process to satisfy the IGSCC inspection requirements.

And some of the samples that were being used under the old program were put into the new program. And I think your second question was basically when people replace their piping, are they still using the qualified methods?

And I would like to wait until Bob Herman gets here and confirms exactly what they're doing, and let you know. But my -- I think that they are still going through the qualifications for the BWR piping.

And it would be either under the old agreement or under the new PDI program depending on how recently they qualified and those sort of considerations.

ACTING CHAIRMAN SEALE: Any other comments or questions? Yes?

MR. DUDLEY: Is there any way to train an inspector to improve his POD in sizing capabilities?

DR. MUSCARA: Yes, there are a number of ways. The first one, of course, is to have capable techniques, and those should be based on the physics of the inspection, not necessarily responsive to --

MEMBER KRESS: We need a microphone here.

DR. MUSCARA: Yes, so the first thing to do is to improve the capability of the techniques. And the second item is really to train the inspectors.

One of the things we found, for example, in

IGSCC detection and sizing is that the passing rate again was very low, 40 percent, for new inspectors going through the process.

But once the inspector qualifies, he does a reasonably good job of detecting and sizing these flaws.

On the other hand, we found that if the inspector does not do an inspection for about a six-month period, he's forgotten all that he's learned, or has adapted learning that he had developed in his mind. Quite often it's gone.

So if a person does not look about samples for about 36 months, we found that his POD and his sizing accuracy goes way down again.

So, it's very important that these inspectors be exposed to conducting inspections and to looking at flaws.

Now, conducting an inspection alone is not necessarily enough. Because if you do a field inspection, very often you do not see flaws so that you do not get the chance to go over the argument in your mind on how to detect and size this flaw.

And so what one should be doing is to be looking at samples that have flaws. Recognizing that in the Appendix VIII requirements, we had some language that required a qualified inspector to go back on an annual

basis for what we called "maintenance training."

And this maintenance training is supposed to provide the inspector with new information about flaws and about techniques, but particularly to allow him some time with samples, to essentially go over his technique on some real samples so he can review and evaluate real flaws again.

Now when we started out, we had about a 40-hour requirement in the Appendix VIII. As the appendix worked its way through the different Code committees, it wound up with -- I believe it was ten hours, eight or ten hours.

I personally feel that that is not enough, and I think there are several others on the Staff that believe that's not really quite enough training.

But the experience is there. If you do not perform an investigation and maintain your capability, you forget it. And it's a reasonably short time when you do forget it. As I say, we found it's about six months.

So, I'm not sure how -- you know, how well I answered that. But capability is important in maintaining experience with the operators.

ACTING CHAIRMAN SEALE: Anything else? Okay. Well, we're a little ahead of schedule here.

MEMBER SHACK: We could take a break.

ACTING CHAIRMAN SEALE: I guess we had better take a break.

(Whereupon, the proceedings went off the record at 2:30 p.m. and resumed at 2:55 p.m.)

MEMBER SEALE: You're still in --

CHAIRMAN SHACK: No, this one I think I'm actually okay. I don't work for Bob.

MR. HERMAN: My name is Robert Herman. I'm a Senior Level Advisor for Material Science, and I'm here today to talk to you about the use of ultrasonic testing in in-service inspection programs.

And it's basically a generic letter that we've got out on Appendix VIII.

I guess I'll digress a little bit before I get started. I never thought I'd sit here and say it's a pleasure to come over and talk to the Subcommittee of the ACRS. But after last night --

(Laughter.)

MEMBER SEALE: Well instead of asking you how -- why you think you're qualified to be here, which is the freshman question, maybe I'll ask the post-grad question. What did you do last night?

MR. HERMAN: I went over and we had a meeting with Niagara Mohawk on core shroud cracking. And subsequent to the meeting, we had a three, three and a

half hour public meeting on the subject after the technical meeting.

And so if I start talking about core shroud cracking halfway through this, don't be surprised.

Anyway with that, for a little background on this, in 1970, the NRC observed the fact that improvements were needed in UT to detect and size flaws; in particular with BWR pipe cracks. There were too many examinations where water dripped on the examiner's head following the examination.

There were also other problems with trying to characterize cracks in feedwater nozzles and BWR problems -- the same problem really in PWRs. The reactor vessel exams, a question about how good the exams were.

What's happened with regard to the background of this? NUREG-0313 had recommendations in it for a UT examiner performance demonstration, which was the tri-party initiative between NRC, EPRI and the industry to get examiners done.

There was a coordination plan developed between the folks I just mentioned. NUREG-0619, which was the BWR feedwater NUREG, recognized that UT needed to be improved. And one of the things they were doing on that periodic dropping of the water and the reactor vessel and going in and having to do surface exams of the nozzles

periodically to ensure that no cracks had initiated, because there was a question about the ability of the UT.

The third thing: reg guide came out later, 1.159, REV 1, on how to do a UT of a reactor vessel.

What's on the street right now? Talk about regulatory requirements for Codes and Standards Rules. 50.55(a) is the Codes and Standards Rules in Section XI. What's currently in place is through the 1989 addenda.

This addenda does not include the requirements to implement Appendix VIII. UT exams methods are required to meet minimum inspection standards.

Most of the things that are in the Code nowadays are methods that amplitude-based. They're prescriptive methods, and they don't require any qualification.

Appendix VIII was incorporated into the 1989 addenda to the Code, Section XI, which was the first time that a performance demonstration came into -- as a Code requirement. It's not an NRC requirement, it's a Code requirement.

Currently, we're in a rulemaking package. The slide that's referenced up here talks about the 1995 addition for bringing up the rulemaking.

Actually, wer'e going to go through the 1996 addenda I believe.

The rulemaking is expected in July of 1998. Any changes scheduled, Jack, in the last week?

MR. STROSNIDER: Not that I'm aware of at this point.

MR. HERMAN: Okay, this has been a problem. I don't know if you all have had a presentation on trying to get this rule out of the House, but it's been aggravation for three years now, or two years.

The performance demonstration initiative was established to manage implementation of Appendix VIII. Basically, PDI is working on qualifications for reactor vessel exams for piping and for bolting.

There are some other things that are in the appendices that are in the Code which aren't a part of the PDI program yet. That will be debated at another time.

And what is Appendix VIII? Appendix VIII is a mandatory appendix in the boiler and vessel -- excuse me, core shroud cracking -- in the boiler and pressure vessel code in Section XI and the '89 addenda.

And effectively what this is doing is going -- taking the examination methods and requiring performance demonstration of the equipment, the procedures and personnel that -- what you're really getting into is a performance-based inspection is what it really is when you finish it.

The testing is on the equipment, the procedures, and the personnel, both to detect its size flaw. I'm not going to read you the numbers. These are the pass/fail rates that have come up using Appendix VIII. And it's a highly effective method, in our view, to qualify UT systems.

MEMBER SEALE: Excuse me, Bob. I'm sure you've sliced and diced these data every way. Let's -- have you looked at it, for example, for a given set of test specimens to see how many people you'd have to have look at the same specimen --

MR. HERMAN: Joe?

MEMBER SEALE: -- and be assured that -- let's say you had a 95 percent probability that one of them would have caught it or something like that?

I mean, one of the concerns I have: is the problem with the specimen or is it with the detector?

MR. HERMAN: Well, a general comment to that?

MEMBER SEALE: Yes.

MR. HERMAN: I don't think the PDI program itself is a statistically based program, correct?

MR. STROSNIDER: This is Jack Strosnider. Let me take a shot at it --

MEMBER SEALE: Jack?

MR. STROSNIDER: -- and give you some

information along that line.

MEMBER SEALE: Okay.

MR. STROSNIDER: As Dr. Muscara indicated, there is, in fact, statistical basis to the PDI program, but it's not -- there are not enough specimens in the program to give you an actual probability of detection.

But the way it was formulated is with the strategy of having a poor team; that is, with the low probability of detection, poor sizing capabilities, rejected most of the time, and a good team accepted most of the time. And Dr. Muscara presented some of those results.

MEMBER SEALE: Yes.

MR. STRCSNIDER: The data -- if you could go back for just a second, Bob, to the viewgraph you had up there. The data which indicates that the failure rates, in the middle of the page there --

MEMBER SEALE: Yes.

MR. STROSNIDER: -- that basically, we went down to PDI and did an audit of the program. And they had put a significant number of people through the program already.

And we went through their records to find how many people were passing or failing the qualifications. These, for the most part, are people who were already

qualified going back in for requalification.

MEMBER SEALE: Damn.

MR. STROSNIDER: Again where you see 22 percent failed to qualify for flaw detection, I can't tell you exactly what their probability of detection was, okay? But I can tell you that the statistics were trying to screen out bad teams and past good teams in accordance with the numbers that Dr. Muscara gave you.

But when we looked at those results, it was very clear that the program is effective and that there are, in addition, a number of people out there who can't meet those minimum requirements.

Now with regard to a specific specimen, and is the problem with regard to the flaw or is it with regard to the people? I guess one thing I could point out is that those statistics -- a lot of those people or teams doing those inspections were using the same equipment and the same procedures. It's from person to person.

And you can also look through some of the specimens, and you'll find that some of the specimens were more difficult for the inspectors than others. And there are some specimens in there that trip them up routinely.

And then some of the questions we've asked ourselves is well, if some of those more difficult samples are not in the sample that someone qualifies on, is that

really a fair qualification. And that's a possibility and we're looking at it. We're trying to figure out exactly what to do with it.

I think, you know, we'll bring that to you guys' attention. But I guess that's the information I could give you. Bill, did you want to add something to that?

MEMBER SEALE: I think you're still all right.

DR. MUSCARA: Yes, we do have some information to try and answer the questions that the specimens versus the people. In effect, most of the time what we're looking at is upper bound values here because assembles are usually much simpler than what you're facing in an actual field inspection.

The work that is going on in the IGSCC, those are realistic samples. Those are real cracks and they are difficult to detect. And that's why you see the passing rate as being fairly low, about 40 percent for the first time around.

We have found that thermal fatigue cracks, which are a reasonably rough crack and fairly tight because of the process itself, is as difficult to detect as a stress corrosion crack, because it is tight.

But many of the tests that -- one of the test data, for example, they were using notches, fairly tight,

sharp notches, nevertheless notches.

So what we're looking at usually is an upper bound. We haven't looked at how many specimens do we need to obtain a certain confidence and a certain probability of detection. We've done this in conjunction with our water steam generators.

But if you're looking at trying to determine a 95 percent probability detection with 95 percent competence, you'll need close to 400 specimens.

MEMBER SEALE: Yes.

DR. MUSCARA: That's why we went to this idea of screening these factors for performance demonstration. It's just not doable. But once the program is in place and it's in place for a number of years, and many inspectors go through, then we could say something about the statistics of the population if not of the individual inspector.

But if we're doing work where we need to know what the POD is, for example the PTS issue, then I don't see any other way out but to run enough specimens with the appropriate personnel, procedures and equipment to get some feeling for what the POD is for the crack size of interest.

MR. HERMAN: On the issue of the program itself, I got back from a meeting that was an IAEA meeting

on qualifications. And there's quite a bit of a different approach in Europe on qualifications than here.

We're using a technique where we go through and qualify the procedures and the equipment first with, let's say, a warm up period for that and then a closed test, and then qualify the examiners.

The European approach is what they call an "open approach." They put together a qualification dossier, which is theoretical background on why the procedure would work.

They collect information on where it's been used in the past, things like that, and don't do a blind test of the procedure and equipment qualification.

They do do the examiners, and that's something that's in the midst of trying to get resolved. We kind of make noises that well, we can't do something the same as the Europeans as part of getting ready to take the test.

But we have the additional feature of a blind test, which you have to find all the flaws in to qualify the procedures and the equipment.

So, that's still up in the air a little bit too in terms of the international aspects of it.

MEMBER SEALE: One other comment --

MR. HERMAN: Sure.

MEMBER SEALE: -- that I'm sure won't give you

any help, but I'll make it anyway. When I see that kind of failure rates with people who have been qualified, it makes me wonder if there aren't good days and bad days.

In other words, the performance of an individual may vary somewhat from time to time because of whatever.

MR. HERMAN: It seems like some -- one of the -- one of the things, at least on the detection, and correct me if I'm wrong -- I think there were some fairly tight fatigue cracks, some particularly difficult cracks to find.

MEMBER SEALE: Yes.

MR. HERMAN: And I think that was part of what was driving our rate up.

DR. MUSCARA: May I add something to that?

MEMBER SEALE: Yes.

DR. MUSCARA: This is Joe Muscara with the Staff. You're quite right. It -- sometimes it is, you know, a bad day for an inspector.

In the test program, we conducted an action which was a human factors action. And one of the tests we conducted was essentially to have several commercial inspectors participate in a test where he was being viewed as to what he was doing and how he was performing.

He was exposed to a number of samples for a

period of two weeks, and then his performance was evaluated.

And in fact, what we found was that the inspector does not perform very well at the beginning of his task. So the first two or three days, he performs at sort of a middle level.

MEMBER SEALE: Yes.

DR. MUSCARA: In the middle of his campaign, he performs much better. And towards the end of the campaign, he's excited about going home, and he's performing more poorly.

Other things that they looked at were the effect of the environment. If there's a lot of heat and humidity, he doesn't perform nearly as well. We expected that.

But they also added some information on the length of the inspection day.

MEMBER SEALE: Yes.

DR. MUSCARA: And what they found was that an eight-hour day was okay. He performed at his normal level. A ten-hour day was okay, but a 12-hour day was not. His performance was really quite poor at ten versus 12 hours.

And that's something that I didn't discuss, but that's something we need to consider in doing a

performance demonstration program.

Should we get the inspector when he's fresh in the morning and have him do the test? Or should he be conducting a test for eight hours and then grade him on the last two hours of the test?

I mean, in the field, after all, they do work 12 hour shifts, and sometimes more.

MEMBER SEALE: Oh yes.

DR. MUSCARA: So, it's an important factor. How fresh is the inspector, and how long has he been at his task?

MEMBER SEALE: And don't buy a car that was assembled on a Monday or a Friday.

(Laughter.)

MR. HERMAN: In getting back to this --

MEMBER SEALE: Sorry.

MR. HERMAN: No, that's all right. Why do we need Appendix VIII? And I think the answer to it is that we think that the existing regulatory requirements might not be adequate to ensure that flaws can be reliably detected.

I've got a couple of examples down here. There's probably some debate about the examples. The Browns Ferry situation -- the fact of the matter, if you ran one procedure with Section XI using the prescriptive

exam, you had to evaluate two flaws.

If you ran the Appendix VIII qualifying procedure, you had to do 15.

Now, the significance of what that was, I'm sure that that's -- that that, in itself, is a terribly significant issue. I think a lot of those were embedded indications that probably weren't too significant anyway.

But the fact of the matter is, the more qualified -- the exam that was qualified was a more stringent exam and identified more defects.

The second item is IGSCC detection in piping at Millstone. A new technique was discovered where they identified 35 cracks, and 14 of them were previously identified as geometry or non-metallurgical type indications. That's true with the new technique.

There's also some question on the Millstone data, whether or not they knew about it the first go-around and whether they should have been called IGSCC cracks the first time.

So you know, there are examples, but I wouldn't -- I wouldn't get overboard with them.

I think the fact of the matter though is that we're pretty sure that a demonstrated UT method is a lot better for doing piping exams, doing vessel exams, than what we're working with today.

And the question is that why do we need a generic letter? We think that the generic letter is important now, especially in the interim until rulemaking comes out, to emphasis the importance of Appendix VIII, that we get qualified examinations that really do the job.

I think both the industry and the NRC recognize that performance demonstration is needed. There's a PDI program established to try to implement most of the requirements in Appendix VIII.

And I don't think it's a question that it's needed. A problem that we have now is the rule, if it stays on the schedule that we're talking about, is not expected to become a requirement until July of 1998.

The generic letter, in our view, will show support for Appendix VIII right now, and it will also indicate NRC support for the PDI initiative.

The program at PDI has been underway for, what, three years is it, Ben?

DR. MUSCARA: Five years.

MR. HERMAN: Five years. And what I would guess, $8 million, $10 million, maybe more.

DR. MUSCARA: Eleven million.

MR. HERMAN: Eleven million dollars. It wasn't a bad guess at the numbers. And what's happening, it's running out of gas in terms of industry support

because the update to the rulemaking process has been delayed. And there's no requirement on the street. Money is getting tough, and people are saying "Why do I need to do this if there's no requirement on the street to do it?"

The generic letter, excuse me, will encourage licensees to use Appendix VIII for the upcoming augmented vessel exams.

Recently, the rules were changed to require 100 percent of reactor vessel inspections, and within a time period. That time period is about up. And if people are doing the exams, some vendors are already qualified.

And we think it would be good, especially depending on how often you're going to do that inspection, to get a good baseline on what's in those reactor vessels. Excuse me.

The purpose of the generic letter is to notify licensees of UT enhancements and deficiencies in the current UT qualifications, determine how the industry plans to ensure that flaws in the reactor vessel and piping are reliably detected in size.

It's basically figure out what the industry is intending to do and determine the extent to which licensees are using or planning to use performance demonstration to qualify UT. Are they committed to do this now or when they do their program updates, or where

do they really stand?

Now, this is the part that Kurt likes the best. It's the regulatory basis for the generic letter. In our view, 50.55(a) requires conformance with ASME III and XI. I don't think there's any questions on that.

One of the things that we're doing is gathering information in this letter to see where we are in terms of requiring augmented inspections. Conceivably if we collected information that the inspections are deficient and people aren't updating their inspections to current programs, there might be a need -- and I say "might" -- to come out with augmented inspection requirements under 50.55(a)(g)(ii).

Also, we're looking for a high assurance that there's -- that GDC 14 is met, that we have confidence that the reactor coolant boundary will have a low probability of leakage, and will be free from rapidly propagating failure and gross rupture.

Further, Appendix B Criterion 16 requires that measures be established to assure conditions adverse to quality are properly identified and corrected.

If you're doing the examinations that you feel are insufficient, it might not meet that Appendix B requirement.

Appendix B Criterion 2 requires QA programs to

take into account the need for verification of quality by inspection and test. Also a program should provide for indoctrination and training of personnel to assure suitably -- suitable proficiency is achieved and maintained. And that's another Appendix B requirement.

How sloshy are those? We probably don't want to debate it today.

The conclusions: experience, such as PISC, BWR pipe inspections, other inspections that have been done on piping. The PDI in Appendix VIII vessel exams indicate that current inspection requirements may not ensure that flaws are reliably detected in size. I don't think anybody will debate that one too much.

Significant improvement can be made in volumetric and NDE reliability if a system is put into place for performance demonstration procedures, equipment, and personnel.

Further, the generic letter will establish to the extent to which Appendix VIII is planned or not for reactor vessel and piping exams, the generic letter, I would argue, would encourage the licensees to use Appendix VIII and perhaps the PDI initiative for implementing Appendix VIII, which has basically been completed for reactor vessel and piping exams.

And the generic letter in our view will

demonstrate the NRC support for Appendix VIII until rulemaking is complete.

Maybe I ought to say a little bit about schedule. The generic letter has been on the street. We have received industry comments. As you might suspect, one of the comments might be, why do you need this thing when you're doing rulemaking? That, and some other issues are under review.

This is not our highest priority generic letter. We're reviewing those comments. And if the rule overtakes the generic letter, then so be it. If it doesn't, then we'll have to cross that bridge when we come to it.

MR. STROSNIDER: This is Jack Strosnider. I'd like to just add a little comment to the conclusions here, the summary. You heard the presentation by Dr. Muscara, and also Bob Herman went back through some of the history on the development of inspection methods to move toward performance based demonstration and the value of it.

But all the discussions were in something of a general -- more of a generic nature. But I do want to point out from the regulator's point of view, when you look at the statistics that came out of our audit, PDI, and you look at the number of inspectors who are failing those tests, it's very difficult as a regulator not to ask

yourself the question at least, are people really providing at a level of quality that you expect from these inspections?

And you look at the statistics associated with those rejections in the statistical design of the test, you look at the failure rates, and you'll say people can do and probably should be doing better, right?

And that's the driving force for this letter is to call that to the attention of the industry, and basically make sure that the industry is assessing it and that they're recognizing the importance of performance demonstration qualification.

So, I think you know, when you get away from just the general concept that this is a good thing to do, we're confronted with some statistics that show very clearly that there's people out there who can't pass this kind of test.

You have to ask yourself the question:  Should they be doing the inspections?  There's a lot of detail that goes around with good day/bad day sort of issues, and how frequently you need to refresh people's memories, et cetera.

But that's all part of the issue here and why the industry needs to pay attention.  And that's really the driving force for this letter.

And the other comment I'd make is we had a lot of discussions within the Agency and with this Committee now about the concept of performance-based regulation.

And I think this is an example of performance-based regulation. Again, we're moving away here from prescriptive methods for inspection and telling the industry we don't care how you do this inspection. You don't have to do this with ultrasonic testing. You can do this with eddy currents or any method you want to use.

You come in and show that you've satisfied these statistics, and this is a performance-based regulation.

And I think there's some meat to it, all right? So, I think it's consistent with our philosophy also, and our regulatory philosophy, of moving toward the performance-based arena.

MR. HERMAN: I think the UT area what you're really getting away from is something where you go out there and do a cookbook for coming up with a UT procedure. And basically, what you do is design a UT procedure that you expect to be able to find the kind of defects that you want to be looking for.

And what the Appendix VIII does is demonstrate that the equipment and the procedures and the people can use that procedure to do the job they're supposed to be

doing.

And with that, I'll say adieu unless you have any further questions.

CHAIRMAN SHACK: Well, I guess, the question is why it takes so long to get 50.55(a) up there.

MR. HERMAN: I'll defer that to management.

(Laugher.)

MR. STROSNIDER: I guess that's me. This is Jack Strosnider. What I'll tell you at this point is that the 50.55(a) package is much broader, of course, than just this issue. And the issue that's been slowing down the promulgation or getting that our for public comment is the update portion.

And that is, how often do licensees need to update their programs in accordance with the Code?

We had a cost beneficial licensing proposal from one of the licensees a couple of years ago. It was probably two and half years or so now, while we were working on this. And you had to go through the assessment of that.

And there's been a number of things that have changed. In going through that process, there are a number of issues that have -- I can't really say anything has changed, but a number of issues that have come up with regard to cost beneficial licensing, which the proposal

was basically to update voluntarily subsequent additions of the Code.

And then we had to go through and decide well, there are parts of the Code that we feel really need to be backfit. Is that the appropriate way to do it? What's the impact if you go to that method on the ASME Code process?

We've had recent discussions with the Commission to say, you know, you ought to make optimal, maximum use of the Code and industry standards.

There's a number of competing considerations with regard to how to do those updates. And quite frankly, it's been bouncing around for some time as to what the most appropriate way to do that is.

In the meantime, this issue and some other issues that are in that rule package have -- have not gotten out for public comment. And we've been pushing hard to get this rule package complete and get it out for comment because these are important issues.

That's about the best explanation I can give you really.

CHAIRMAN SHACK: But I take it from Bob's statement that if I was a utility hiring an inspector, you know, I'd certainly want him qualified. I mean, why waste my time and money on a guy that hasn't passed this course?

MR. STROSNIDER: Well, I think that's a good point. You don't want people out there just going through the motions. You want to know that they are qualified. And I think this letter -- and we've made it clear in this letter and in all our other meetings that we are pursuing implementation of Appendix VIII.

You know, it's a Code, industry-developed standard. It makes sense to us. From what we've seen of its implementation at PDI, it looks like it can significantly enhance the quality.

And that's the direction we're headed, and I think -- I think, you know, it's only fair to let -- make sure the industry is aware of that.

And one of the concerns -- you know, we do -- I want to emphasize, we want to get the rule out as quickly as possible. But recognizing the schedule we're at now -- and another reason for this letter was that we don't want, you know, several more outage seasons to go by before people really take advantage of this qualification method.

So you know, we're asking licensees in this letter, go look at these data, look at the results of this, and convince yourself that you really start a qualification that you ought to have in doing these

inspections.

MR. HERMAN: What I would say right now, I think, to be fair about the thing: times are tough, money is tough. And if it's 150 bucks an hour to get a pipe examiner that's qualified versus not qualified versus a hundred bucks an hour to get somebody that is qualified, and I don't have a requirement to do it, money is tough.

MR. STROSNIDER: You need to understand the utilities are certainly looking at the economic aspects. I don't know how big of an issue that is here. I'm not sure what rates are being -- but you know, regardless of what the economics are, you know, in regard to having a good Appendix B, a good quality inspection, we think this is clearly the sort of thing that people need to be doing.

CHAIRMAN SHACK: If there are no further questions, I think that -- Joe, do you have a comment?

DR. MUSCARA: Maybe I could make a comment. Bob showed you some data from the PDI program on the passing rate of the inspectors that went through. Let's say it was around 40 percent. Well, that means at least if we use a screening test, we choose only the best inspectors to do our inspections.

We have also looked at the capability of inspectors that participated in the PISC exercise on pressure vessel steels. And in effect, we chose those

combinations of inspectors and samples that would have met the Appendix VIII requirements with respect to the numbers and sizes of flaws.

And what we found was that the inspectors that were using effective procedures for the kind of flaws they were trying to detect, would flunk.

But the effective inspectors who had a procedure, for example, for underclad cracking, they would use a procedure that was specifically developed for underclad cracking.

So effective inspectors, the procedures did pass. And then especially if he tells us that it's an Appendix VIII requirement is quite a good one, it does do a good job of screening out poor inspectors whether you're looking at piping or vessel materials.

And it's been shown by the PDI exercises and by the PISC exercises in a subsequent evaluation of those results.

CHAIRMAN SHACK: Well, if there are no further comments, I think we can recess for the day.

(Whereupon, the meeting was concluded at 3:29 p.m.)

# C E R T I F I C A T E

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: MATERIALS AND METALLURGY

Docket Number: N/A

Place of Proceeding: ROCKVILLE, MARYLAND

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Corbett Riner

CORBETT RINER
Official Reporter
Neal R. Gross and Co., Inc.

# INTRODUCTORY STATEMENT BY THE CHAIRMAN OF THE MATERIALS & METALLURGY SUBCOMMITTEE
11545 ROCKVILLE PIKE, ROOM T-2B3
ROCKVILLE, MARYLAND
APRIL 15-16, 1997

The meeting will now come to order. This is the first day of the meeting of the ACRS Subcommittee on Materials & Metallurgy. I am William Shack, Chairman of the Subcommittee. I have a conflict of interest with some topics of today's meeting. During the discussion of those topics, Dr. Robert Seale will serve as Chairman.

The ACRS Members in attendance are:

Thomas Kress and Robert Seale.

The purpose of this meeting is to hold discussions with representatives of the NRC staff and Consumers Power Company concerning generic letters associated with steam generator tube inspection techniques, effective use of ultrasonic testing techniques in inservice inspection programs, degradation of steam generator internals, and degradation of reactor vessel head penetrations. We will also discuss the status of issues related to reactor pressure vessel integrity. The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate, for deliberation by the full Committee.

Noel Dudley is the Cognizant ACRS Staff Engineer for this meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on April 4, 1997.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register Notice. It is requested that the speakers first identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

We have received no written comments or requests for time to make oral statements from members of the public.

(Chairman's Comments, if any)

We will proceed with the meeting and I call upon Stephanie Coffin of NRR to begin.

NRC STAFF PRESENTATION TO THE ACRS

SUBJECT: GENERIC LETTER
"Degradation of Steam Generator Internals"

DATE: April 15, 1997

PRESENTER: Stephanie M. Coffin
Materials Engineer
Materials and Chemical Engineering Branch
Division of Engineering
415-2778

SUBCOMMITTEE: Materials and Metallurgy

## PURPOSE OF GENERIC LETTER

- Communicate findings of damage to steam generator internals at foreign PWR facilities

- Emphasize importance of performing examinations of steam generator internals to ensure steam generator tube structural integrity is maintained

- Request information to verify acceptable condition of steam generator internals

# DAMAGE TO STEAM GENERATOR INTERNALS AT FOREIGN PWR FACILITIES

Plants similar to Westinghouse Model 51 Steam Generators

1) Wastage of the uppermost support plate--
   Misapplication of a chemical cleaning process

2) Broken tube support plate ligaments at uppermost TSP--
   Excessive stress during final thermal treatment

3) Wastage of tube support plates at various elevations--
   Cause is undetermined; not associated with chemical cleaning

4) Tube bundle wrapper drop and cracking of the wrapper--
   Excessive stress during cooling transient, poor welds; cause of cracking unknown

## SIGNIFICANCE OF EVENTS

- Degradation of the tube support plates and the tube bundle wrapper could affect the integrity of the steam generator tubes
- Tube support plates prevent lateral displacement, vibration, and minimize bending moments in the tubes
- Fall of the tube bundle wrapper can lead to a loss of feedwater, damage to steam generator tubes

# FOREIGN RESPONSE TO STEAM GENERATOR INTERNALS DEGRADATION

To detect wastage and cracking of tube support plates:

- Eddy current testing of the steam generator tubes
- Visual and video camera inspections of the secondary side

Response:

- Tubes without adequate lateral support are stabilized and plugged

# FOREIGN RESPONSE TO STEAM GENERATOR INTERNALS DEGRADATION

To detect tube bundle wrapper drop:

- Visual and video camera inspections of the secondary side
- Online instrumentation of the bundle wrapper

Response:

- Repairs completed on damaged bundle wrappers

## DOMESTIC EXPERIENCE

Cracked or deformed tube support plates found at dented intersections in U.S. steam generators (Surry 1&2, Turkey Point 3&4, San Onofre 1, Indian Point 2, Millstone 2)***

EDF experience indicates there may be other mechanisms which lead to support plate damage

- Eddy current indications will be visually inspected this spring outage at Diablo Canyon

- Eddy current and visual inspections performed at Braidwood Unit 1 and Byron Unit 1 found no evidence of tube support plate or tube bundle wrapper degradation

***Except for IP-2, all SGs replaced or plant was shutdown

# APPENDIX B CRITERIA

## CRITERION XI, "TEST CONTROL"

Program shall be established to assure that all testing required to demonstrate that SSCs will perform satisfactorily in service is identified and performed

## CRITERION XVI, "CORRECTIVE ACTION"

Measures shall be established to assure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment and nonconformances are promptly identified and corrected

## REQUESTED INFORMATION

Request the following information:

- Discuss program to detect degradation of internals, if such a program exists
  - Reviews of past eddy current data
  - Secondary side visual/video camera inspection results
  - Description of degradation, how assessed and dispositioned
- Discuss plans for establishing a program or justification as to why no such program is needed

# PUBLIC COMMENTS

NUBARG

- GL implies licensees should perform inspections of SG internals
- Complete a backfit analysis, justify the need for the information and any new positions on inspection requirements

NRC POSITION

- Appendix B Criteria XI and XVI, "Test Control" and "Corrective Action" apply
- GL does not promulgate new or revised staff position or requirements
- GL requests information to assess the applicability of the foreign experience to U.S. SGs

## PUBLIC COMMENTS, continued

NEI

- GL imposes actions for licensees to perform inspections of SG internals

- Industry task force formed which will address GL concerns; no need for GL

NRC POSITION

- GL requests information on actions taken in accordance with Appendix B criteria

- GL needed to obtain and document information from licensees

# STATUS OF GENERIC LETTER

Public comment period expired March 15th

NRC staff addressing comments

Expect coordinated industry response to GL through NSSS vendors and NEI/EPRI

# BACKGROUND ON ULTRASONIC INSPECTION RELIABILITY AND PERFORMANCE DEMONSTRATION

## ACRS SUBCOMMITTEE MEETING
## MATERIALS & METALLURGY
## ROCKVILLE, MARYLAND

April 15, 1997

J. Muscara, Senior Metallurgical Engineer
Electrical, Materials, and Mechanical Engineering Branch
Division of Engineering Technology
Office of Nuclear Regulatory Research

(301) 415-5844

# RESEARCH EFFORTS

PROGRAM TITLE:

Evaluation and Improvements in Nondestructive Examination (NDE) Reliability for Inservice Inspection of Light Water Reactors

Program Initiated in Fiscal year 1977

Program Objectives:

- Determine the reliability of ultrasonic inservice inspections (ISI) performed on commercial, light water reactor pressure vessels and piping.
- Recommend Code changes to the inspection procedures to improve the reliability of ISI.
- Based on the importance of components to safety, material properties, service conditions and NDE uncertainties, formulate improved inservice inspection criteria (including sampling plan, location, frequency and reliability of inspection) to achieve suitably low failure probabilities for the inspected components.

# BACKGROUND

- Cold leg break study - need for NDE reliability data (POD & sizing).
- Concerned about the quality, frequency and extent of the ISI being performed.
- Inability to detect intergranular stress corrosion cracking in the primary piping of BWRs in the early 1970s.
- PVRC and PISC 1 programs identified need for improvements in ASME Code procedures for inspecting pressure vessel steels.

# EVALUATION OF NDE RELIABILITY

- Conducted extensive parametric studies on important inspection variables - 6000 measurements

  - Developed recommendations for improvements in procedures

    RIL #113 in 1981
    ASME Code Case N-335 in 1982

- Conducted two round robin tests to quantify POD as a function of crack size, false call rate, and sizing accuracy.

  - Piping Inspection Round Robin in 1982

    6 ISI teams that conducted 1500 inspections.

  - Mini Round Robin in 1985

    12 individuals and 3 automated inspection teams.

## EVALUATION OF NDE RELIABILITY (Cont.)

PIRR (NUREG/CR-5068)

Clad Ferritic Material - 32" diameter, 2-3/8" wall thickness.

- 16 Thermal Fatigue Cracks
- Length from 1.25" to 3.1"
- Depth from 0.3" to 1.1"

CCSS - 33" diameter, 2-3/8" wall thickness

- 19 Thermal Fatigue Cracks
- Length from 1" to 4"
- Depth from 0.3" to 1.25"

Wrought Stainless Steel - 10" diameter, 0.5" or 0.6" wall thickness

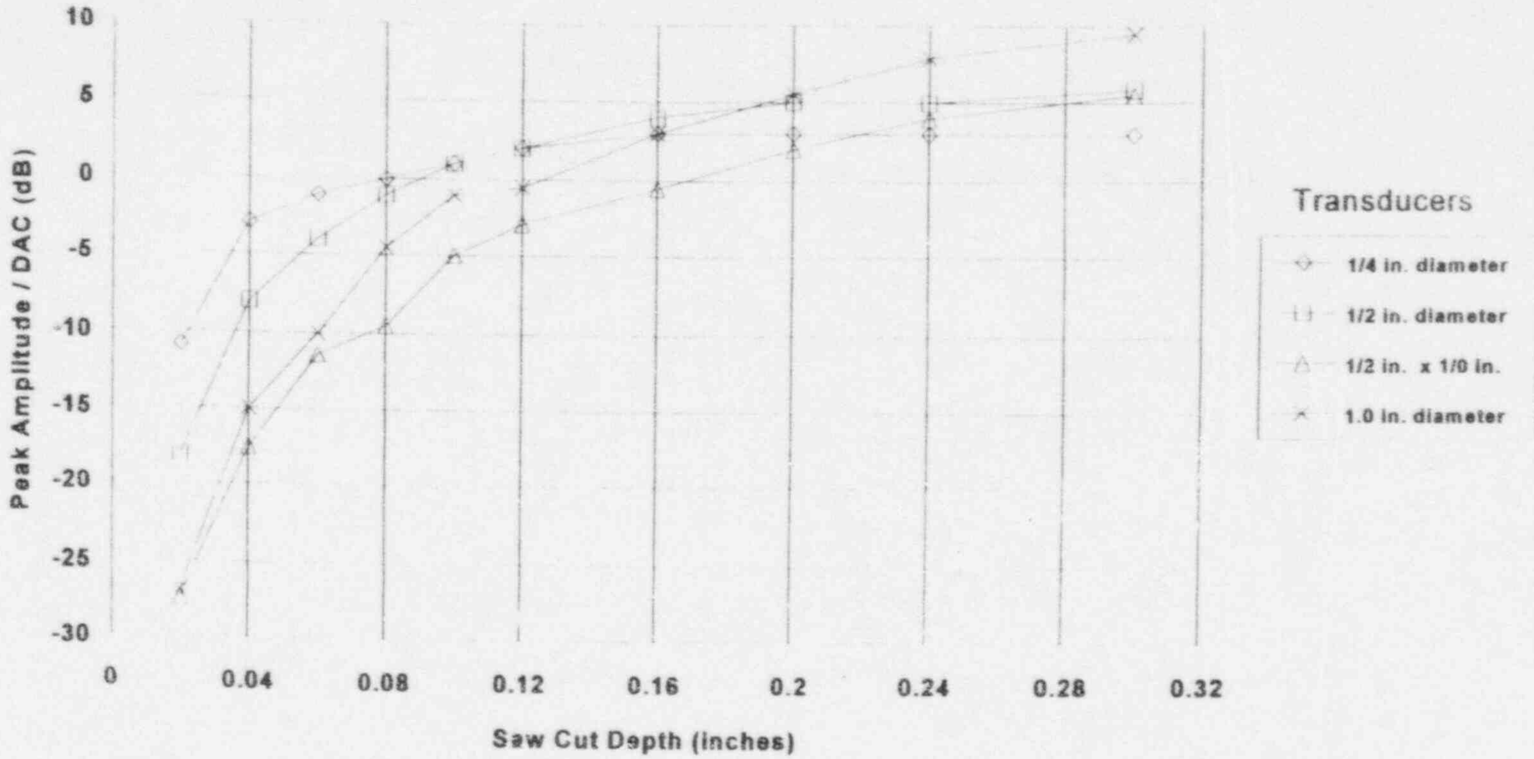
- 23 IGSCC and 28 Thermal Fatigue Cracks
- Length from 0.16" to 2.3" for IGSCC and 0.33" to 2.4" for TFC
- Depth from 0.1" to 0.21" for IGSCC and 0.12" to 0.33" for TFC

# EVALUATION OF NDE RELIABILITY (Cont.)

MRR (NUREG/CR-4908)

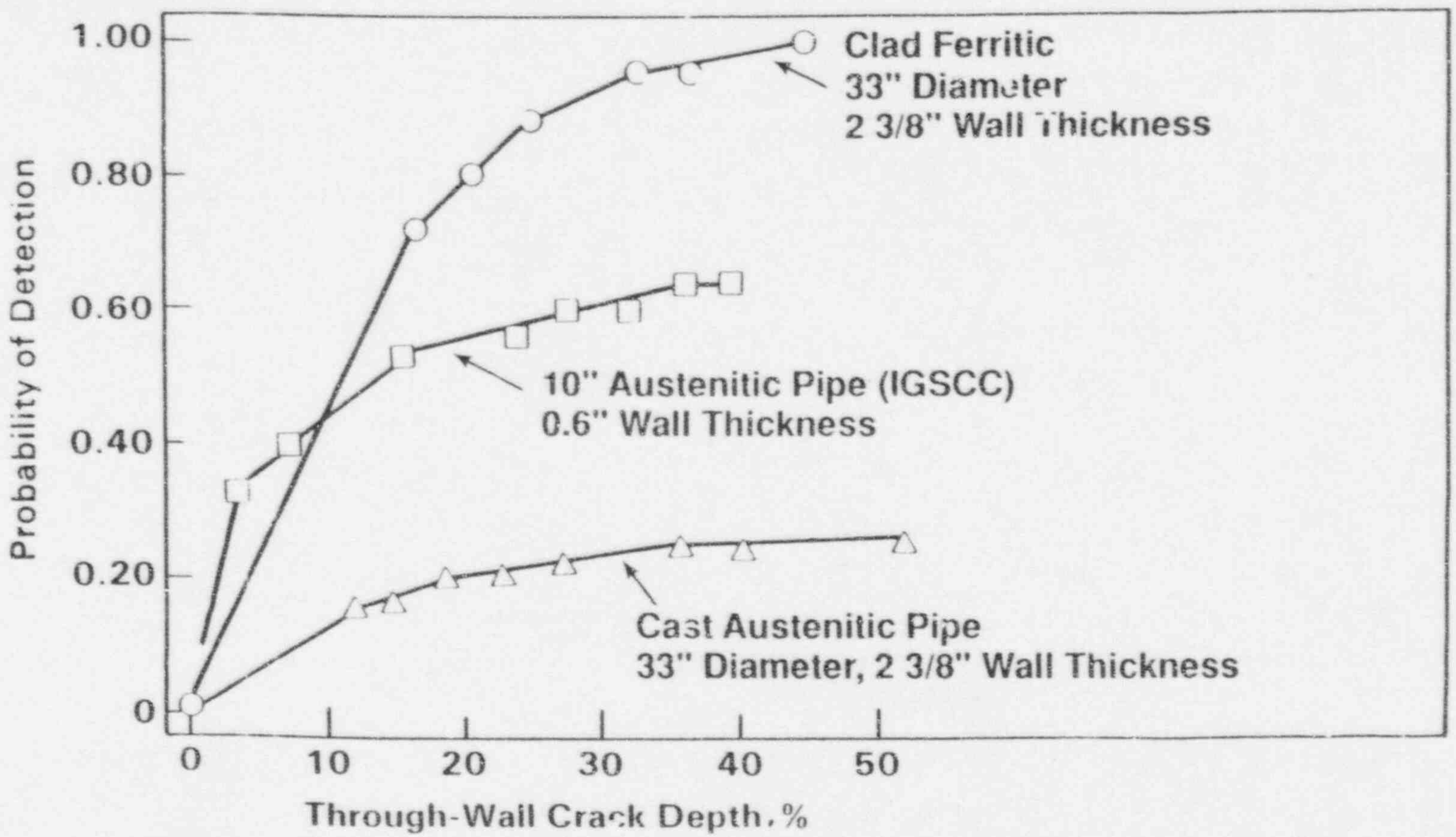
Wrought Stainless Steel - 10"and 12" diameter, 0.6" to 0.85" wall thickness

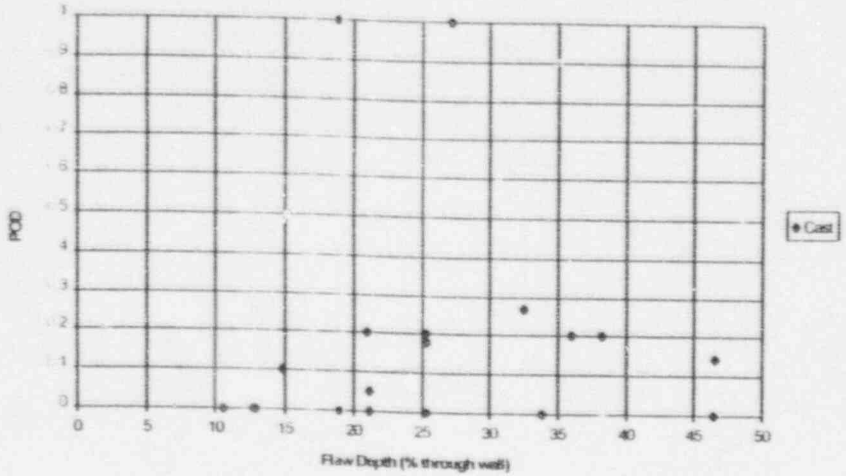
- Total number of IGSCC was 28
- Flaw length varied from less than 1" to 40"
- Flaw depth varied from 0.033" to 0.45"



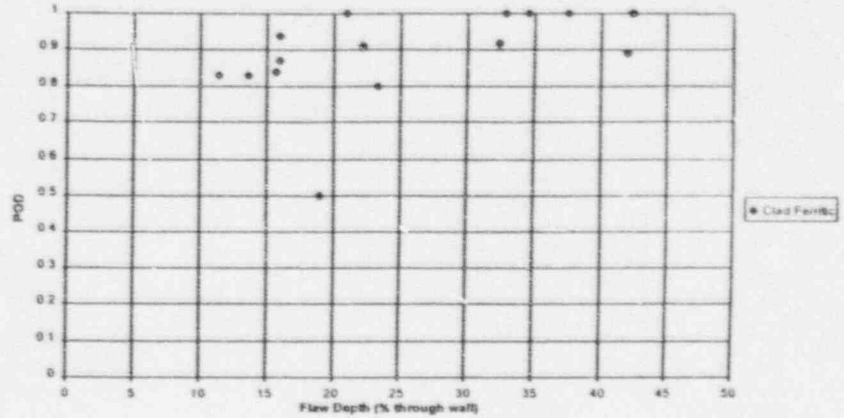

Ultrasonic response from vertical saw cuts for a ½ V path at an inspection angle of 45° for transducer elements of different sizes

# Plot of POD Versus Crack Depth for Clad Ferritic, Wrought Austenitic and Cast Austenitic Pipe

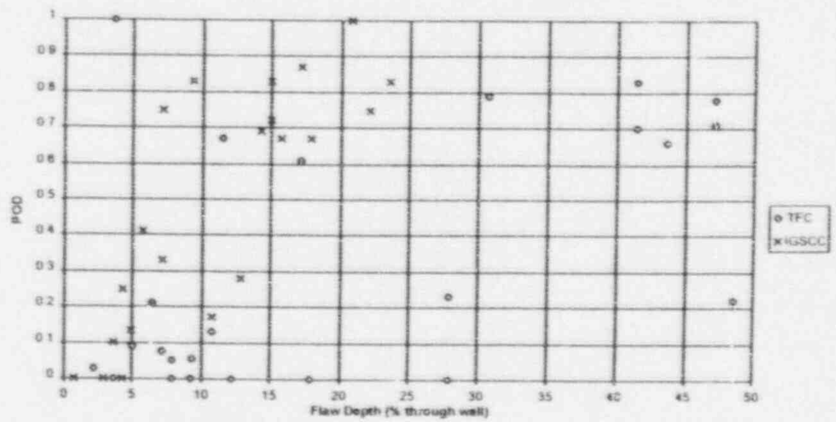





(a)



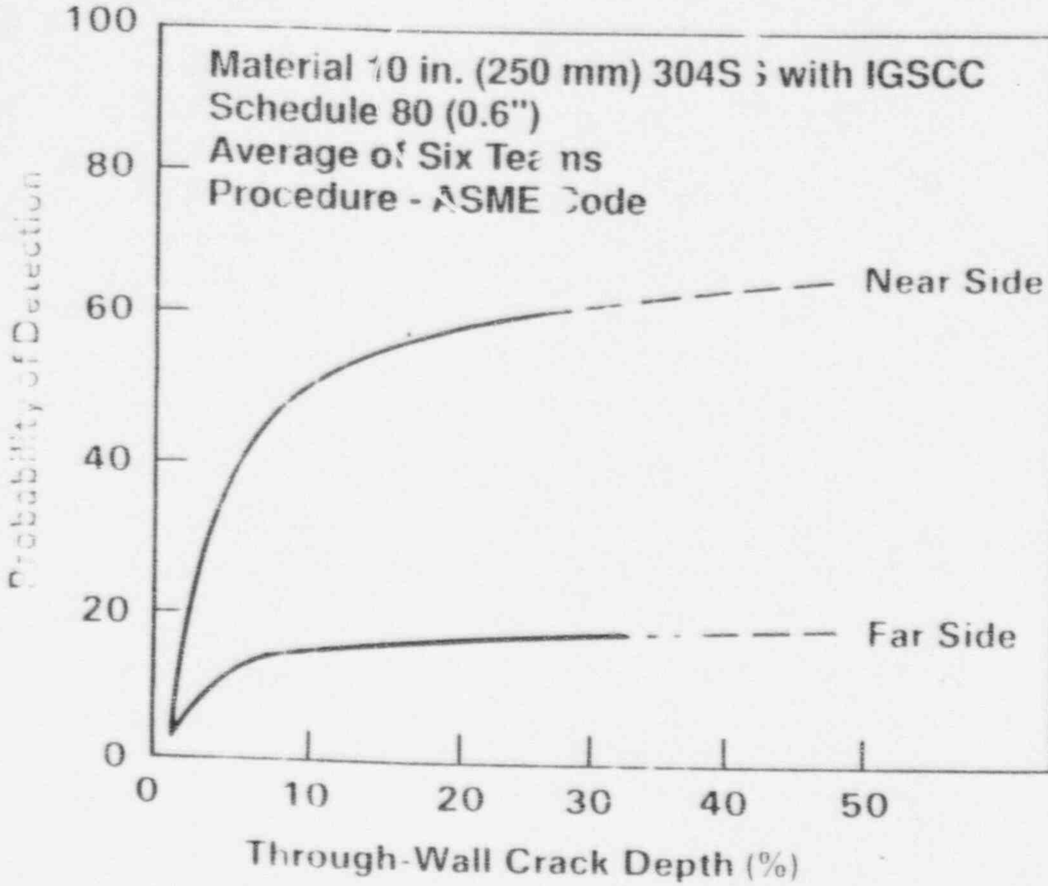

(b)

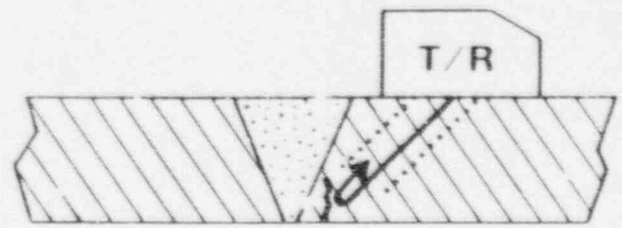



(c)

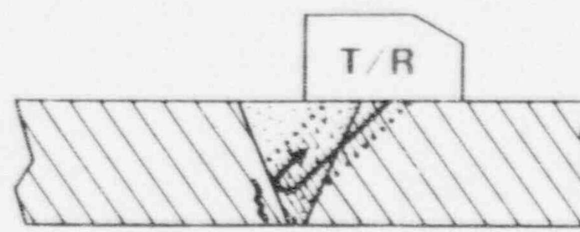
PIRR detection performance conducted in early 1980s for POD versus crack depth in a) centrifugally cast stainless steel, b) clad ferritic, and c) wrought stainless steel with IGSCC and thermal fatigue cracks

# Near Side vs Far Side Inspection Results



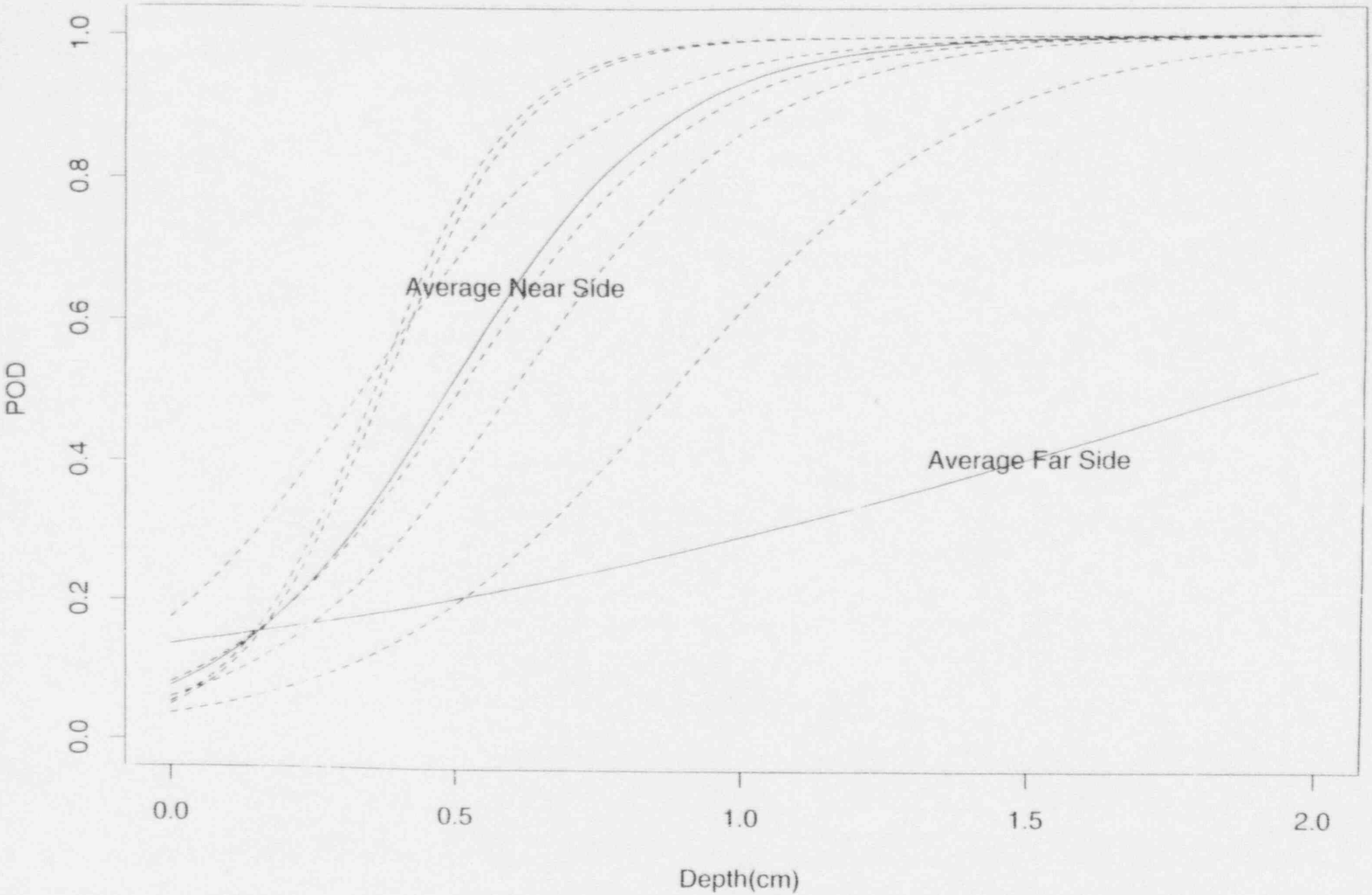



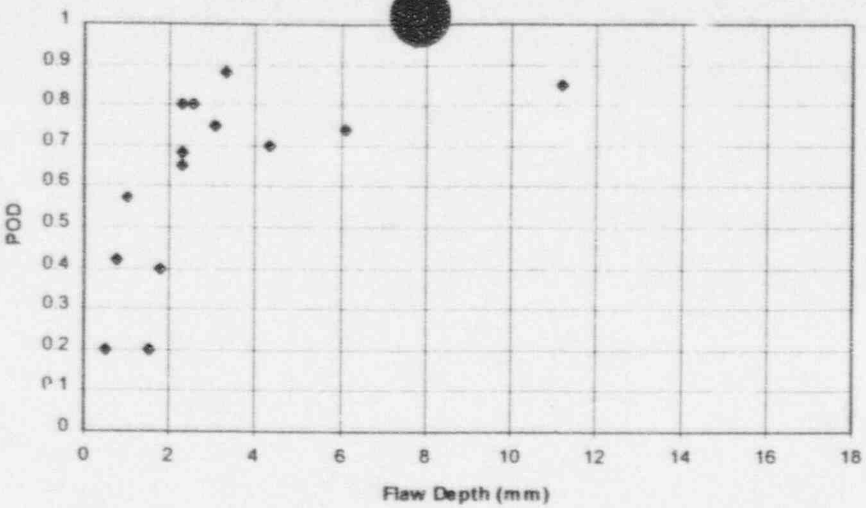

Near Side Access



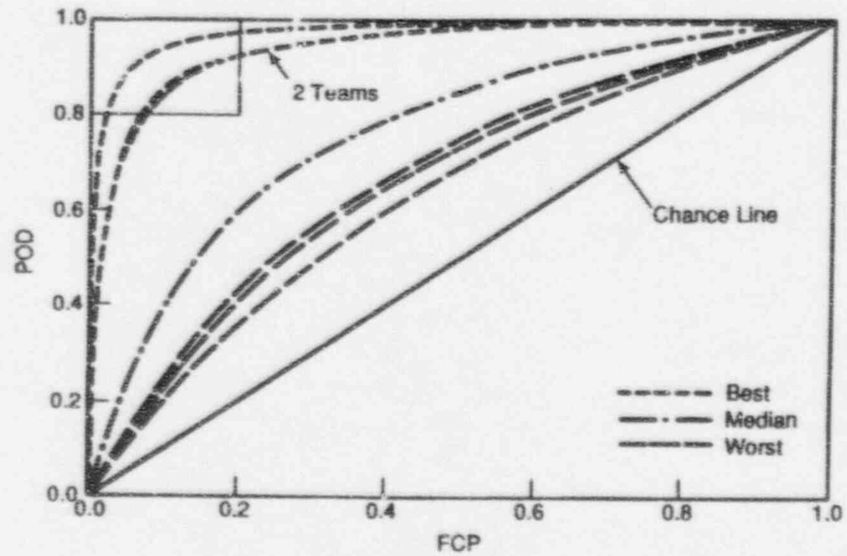

Far Side Access

Probability of Detection Performance for PIRR
Thermal Fatigue Cracks, 304 ss 10" Schedule 80






(a)




(b)

MFR detection performance results of the mid 1980s a) POD versus IGSCC depth in wrought stainless steel and b) POD versus false calls showing 3 best, 3 worst and median performance

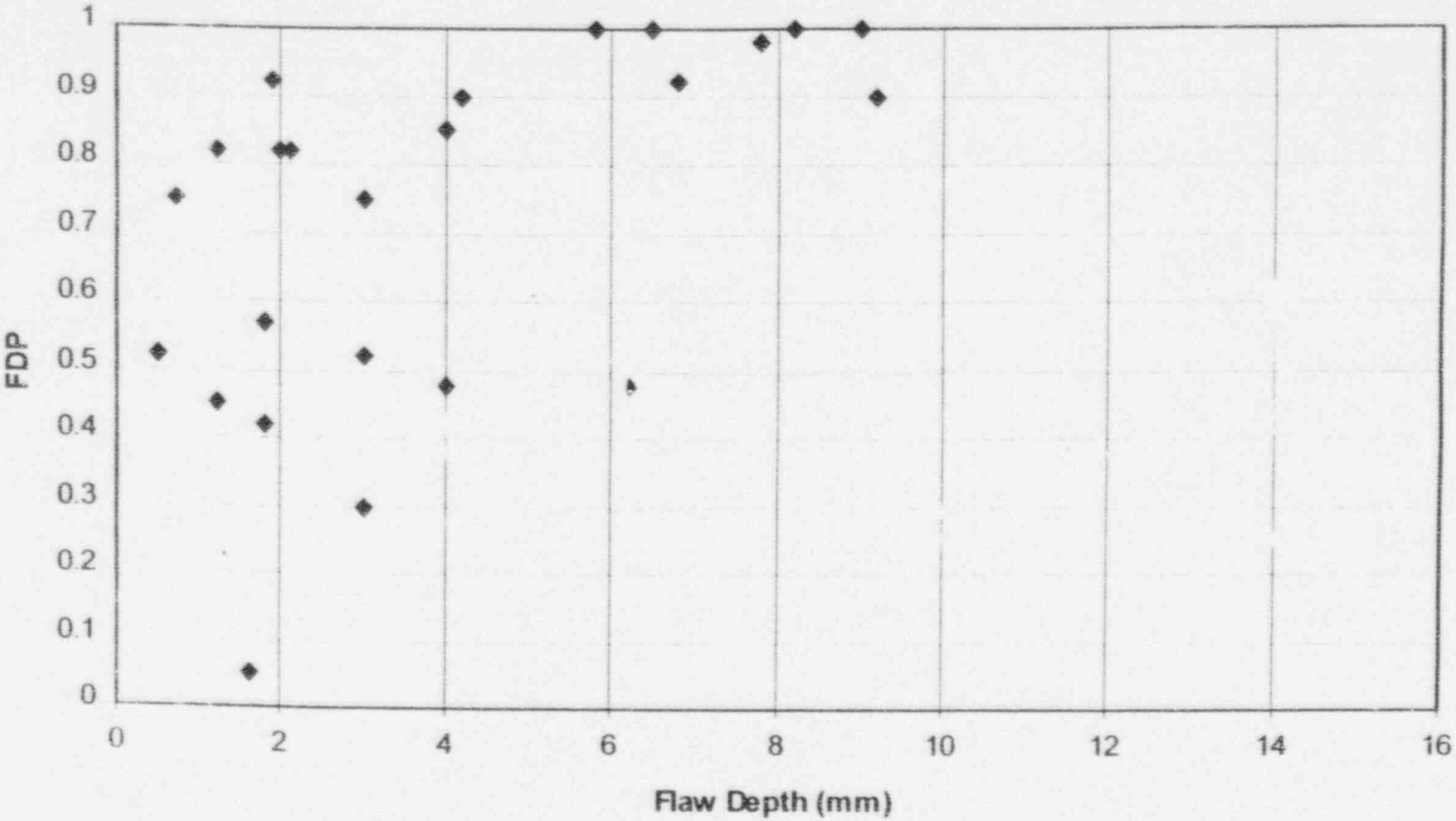
# MRR DETECTION PERFORMANCE FOR IGSCC

Summary of Individual Near-Side Inspector Performance for Both Manual and Advanced Techniques

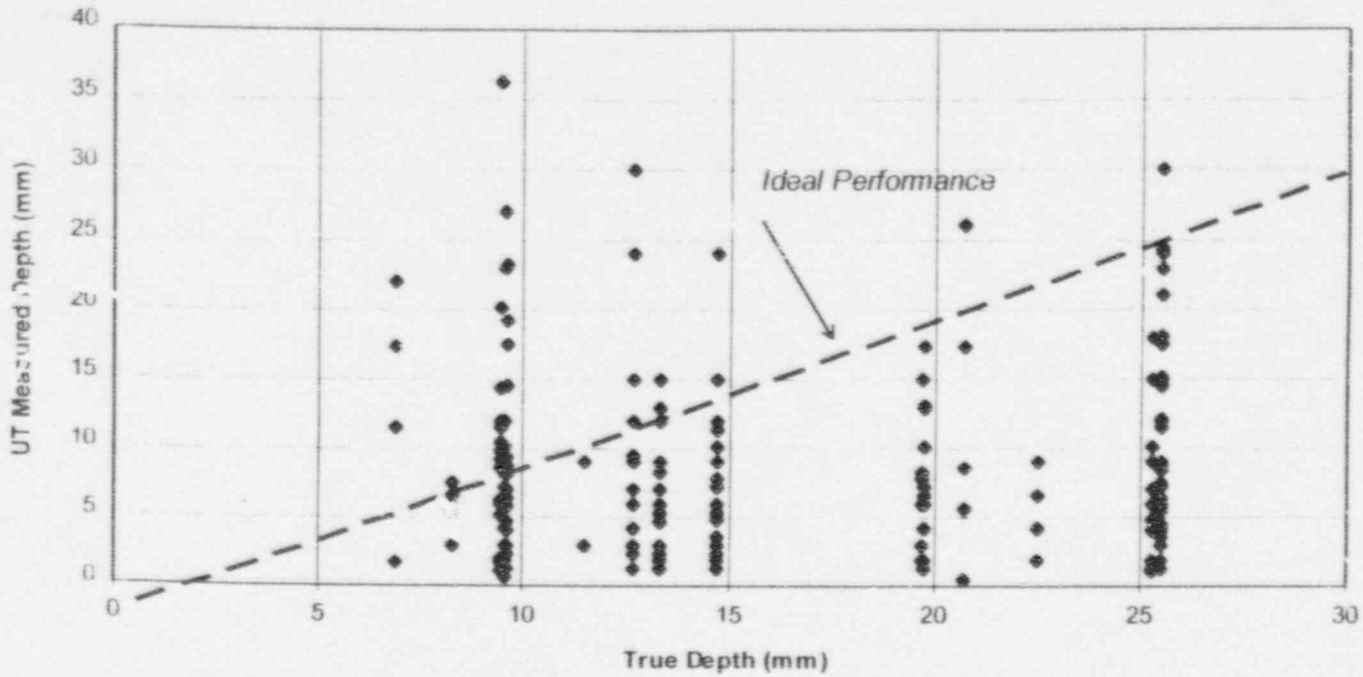
| Inspector | Lower 90% | FCP | Upper 90% | Lower 90% | POD | Upper 90% |
|---|---|---|---|---|---|---|
| 1 | 0.12 | 0.33 | 0.61 | 0.59 | 0.85 | 0.97 |
| 2 | 0.05 | 0.19 | 0.42 | 0.08 | 0.27 | 0.56 |
| 3 | 0.00 | 0.00 | 0.21 | 0.51 | 0.77 | 0.93 |
| 4 | 0.00 | 0.08 | 0.32 | 0.22 | 0.46 | 0.71 |
| 5 | 0.00 | 0.00 | 0.21 | 0.51 | 0.77 | 0.93 |
| 6 | 0.03 | 0.15 | 0.41 | 0.59 | 0.85 | 0.97 |
| 7 | 0.07 | 0.23 | 0.49 | 0.11 | 0.31 | 0.57 |
| 8 | 0.17 | 0.38 | 0.65 | 0.35 | 0.62 | 0.83 |
| 9 | 0.03 | 0.15 | 0.41 | 0.59 | 0.85 | 0.97 |
| 10 | 0.17 | 0.38 | 0.65 | 0.43 | 0.69 | 0.89 |
| 11 | 0.03 | 0.14 | 0.39 | 0.15 | 0.36 | 0.61 |
| 12 | 0.17 | 0.38 | 0.65 | 0.51 | 0.77 | 0.93 |
| 13 | 0.03 | 0.15 | 0.41 | 0.51 | 0.77 | 0.93 |
| 14 | 0.29 | 0.54 | 0.78 | 0.43 | 0.69 | 0.89 |
| 15 | 0.00 | 0.08 | 0.32 | 0.79 | 1.00 | 1.00 |

Summary of Individual Far-Side Inspector Performance for Both Manual and Advanced Techniques

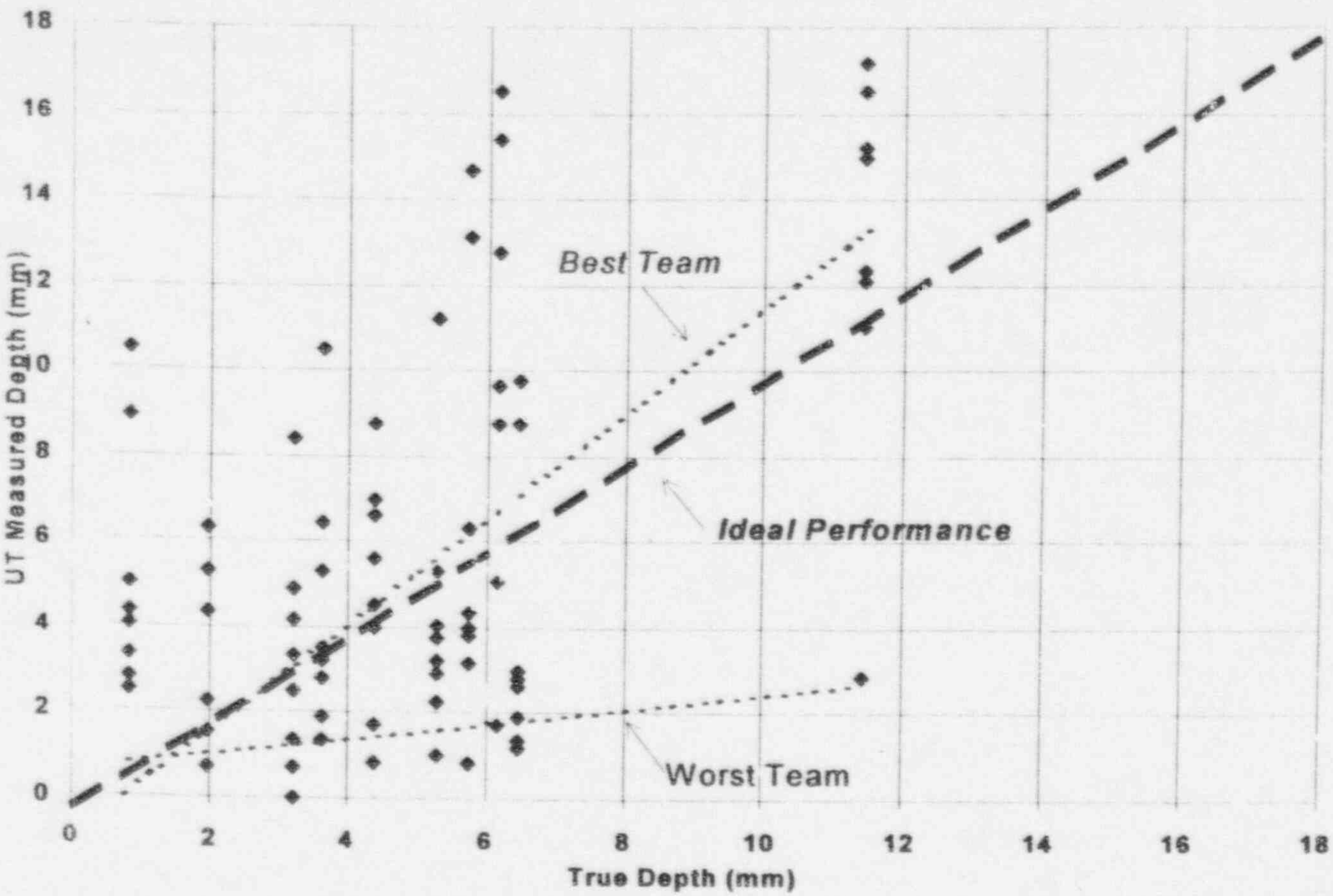
| Inspector | Lower 90% | FCP | Upper 90% | Lower 90% | POD | Upper 90% |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.22 | 0.00 | 0.00 | 0.31 |
| 2 | 0.09 | 0.25 | 0.48 | 0.23 | 0.57 | 0.87 |
| 3 | 0.11 | 0.31 | 0.57 | 0.00 | 0.00 | 0.31 |
| 4 | 0.00 | 0.00 | 0.21 | 0.01 | 0.13 | 0.47 |
| 5 | 0.00 | 0.00 | 0.21 | 0.01 | 0.13 | 0.47 |
| 6 | 0.11 | 0.31 | 0.57 | 0.05 | 0.25 | 0.60 |
| 7 | 0.29 | 0.54 | 0.78 | 0.40 | 0.75 | 0.95 |
| 8 | 0.00 | 0.08 | 0.32 | 0.01 | 0.13 | 0.47 |
| 9 | 0.43 | 0.69 | 0.89 | 0.19 | 0.50 | 0.81 |
| 10 | 0.17 | 0.38 | 0.65 | 0.19 | 0.50 | 0.81 |
| 11 | 0.33 | 0.57 | 0.79 | 0.01 | 0.17 | 0.58 |
| 12 | 0.11 | 0.31 | 0.57 | 0.05 | 0.25 | 0.60 |
| 13 | 0.00 | 0.08 | 0.32 | 0.01 | 0.13 | 0.47 |
| 14 | 0.00 | 0.08 | 0.32 | 0.00 | 0.00 | 0.31 |
| 15 | 0.00 | 0.08 | 0.32 | 0.00 | 0.00 | 0.31 |



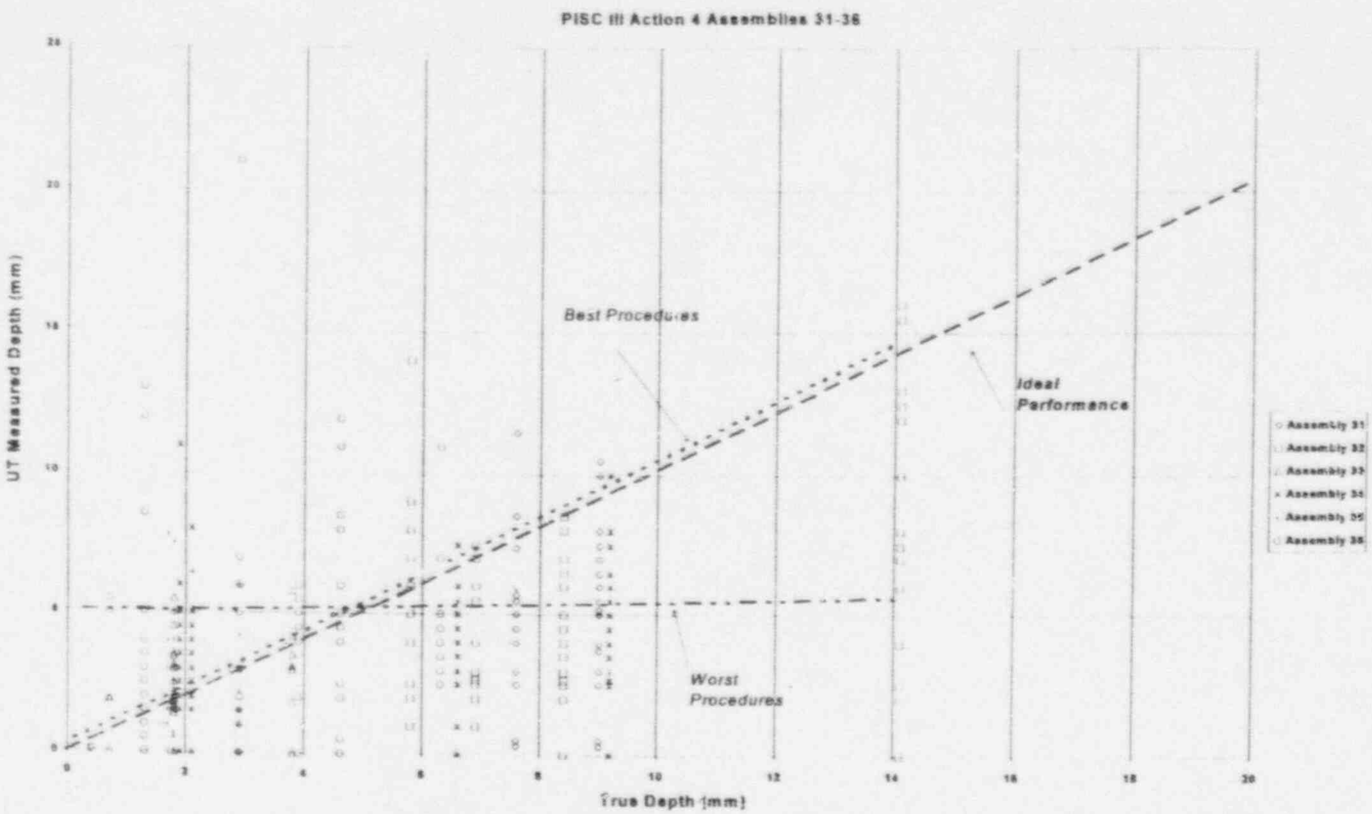

PISC III Action 4 international round robin study on flaw detection probability (FDP) versus flaw depth in wrought stainless steel conducted in late 1980s



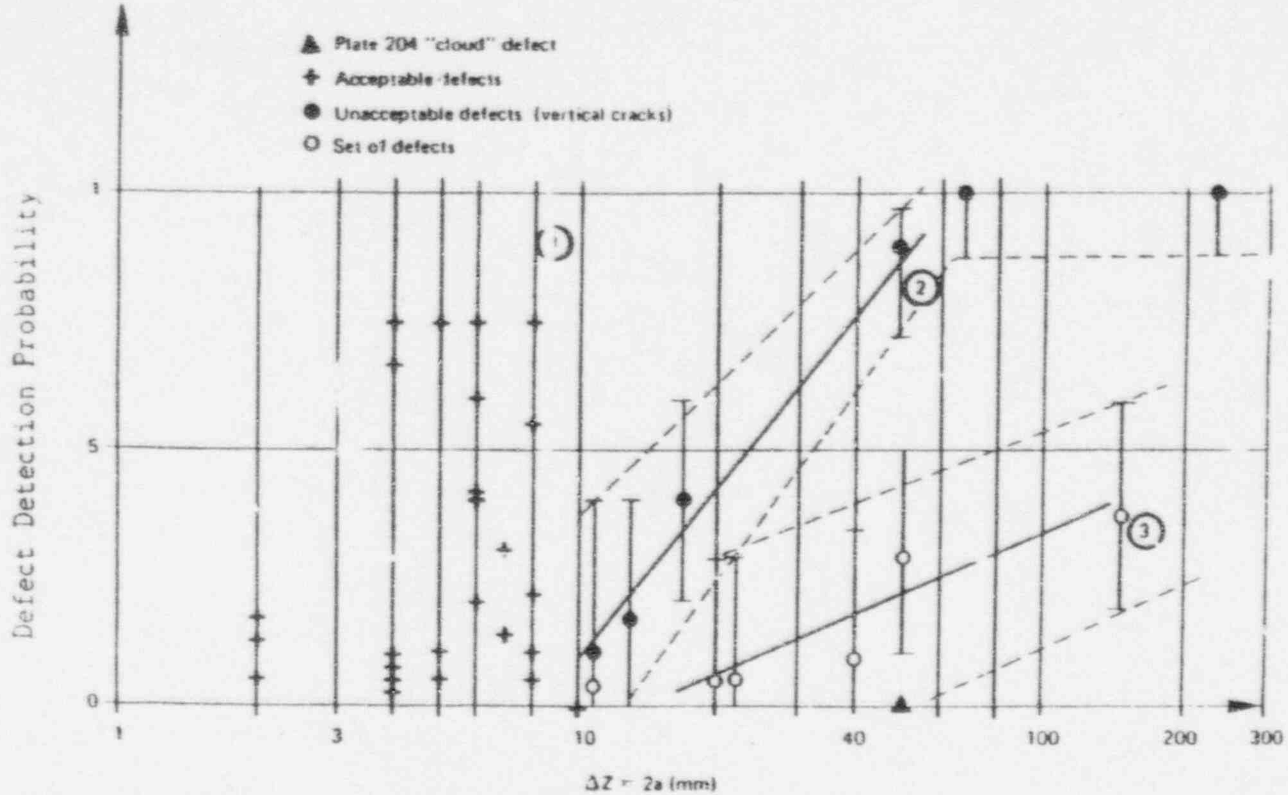

PIRR UT depth measurements on thermal fatigue cracks in clad ferritic piping conducted in the early 1980s




MRR UT depth sizing performance for IGSCC in wrought stainless steel piping conducted in mid-1980s showing best and worst teams




PISC III Action 4 UT depth sizing performance for flaws in wrought stainless steel conducted in late 1980s showing best and worst procedures

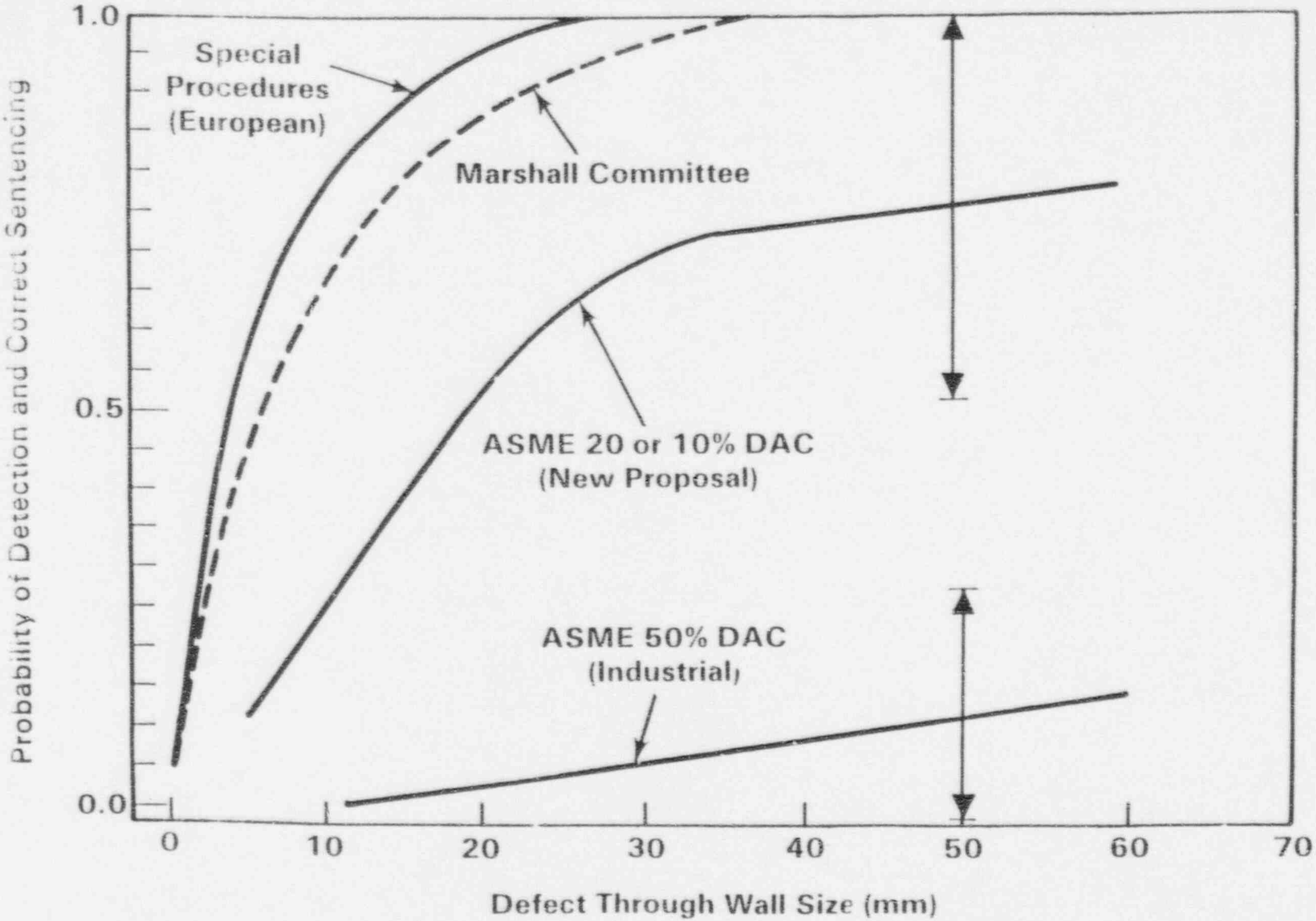


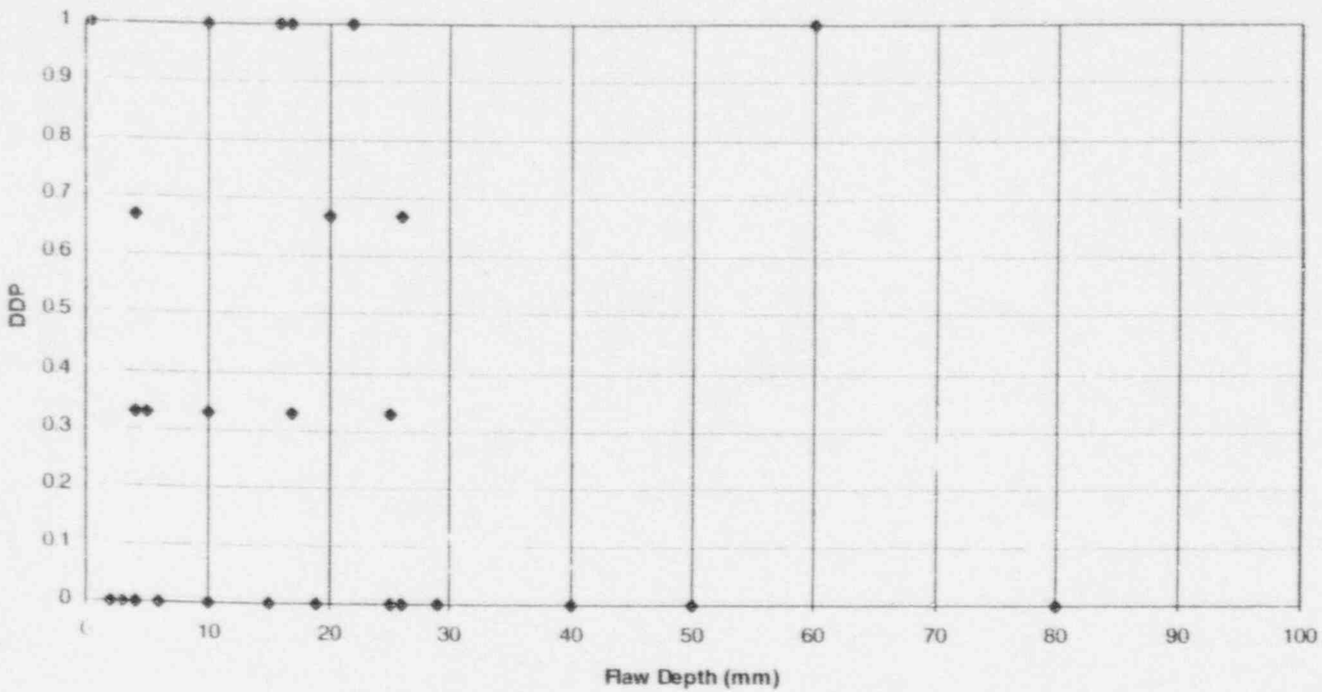

Defect size : dimensions of the defect in the through wall section

Thickness of the plates : from 200 mm to 250 mm

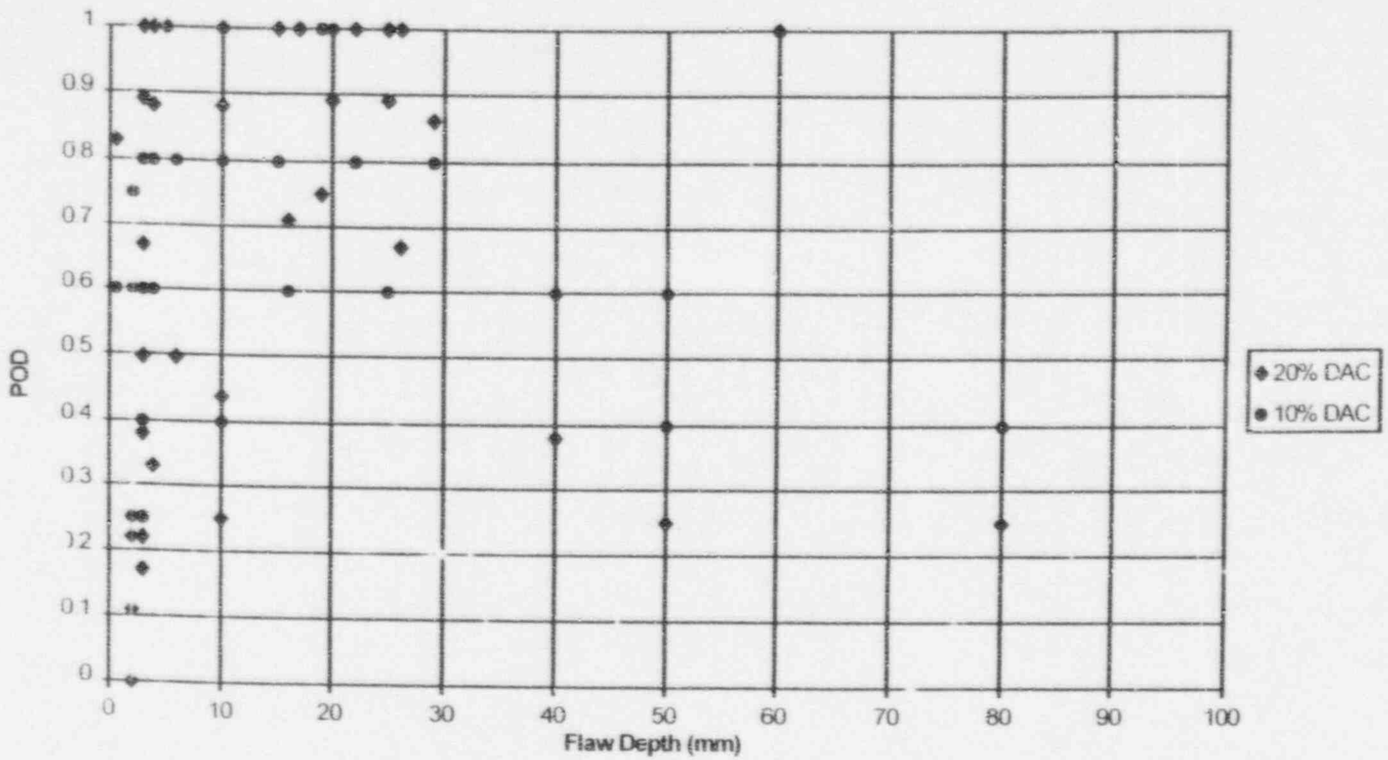
PISC I detection results for defect detection probability versus defect depth using 1974 ASME Section XI Code type procedures at sensitivity of 50% DAC

# PISC II RRT Results for Selected Procedures for Plate No. 3

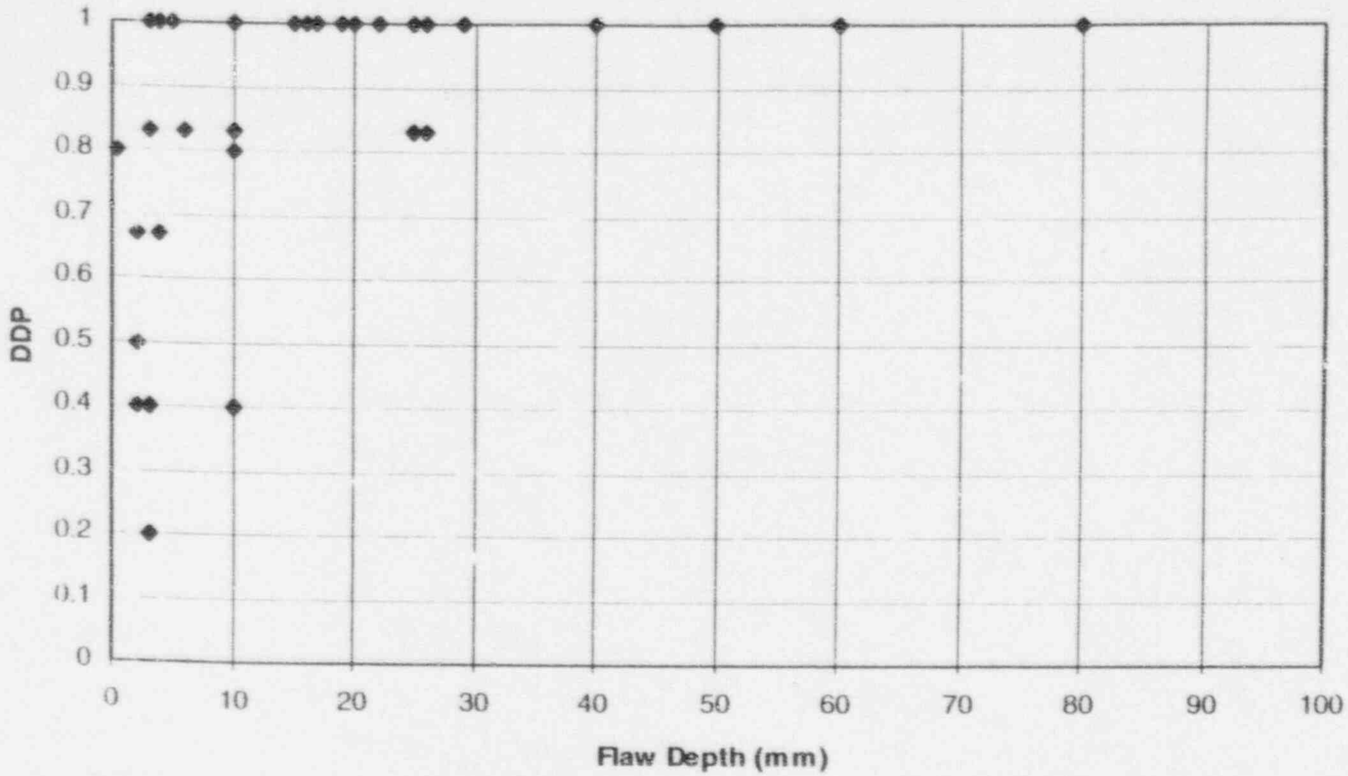




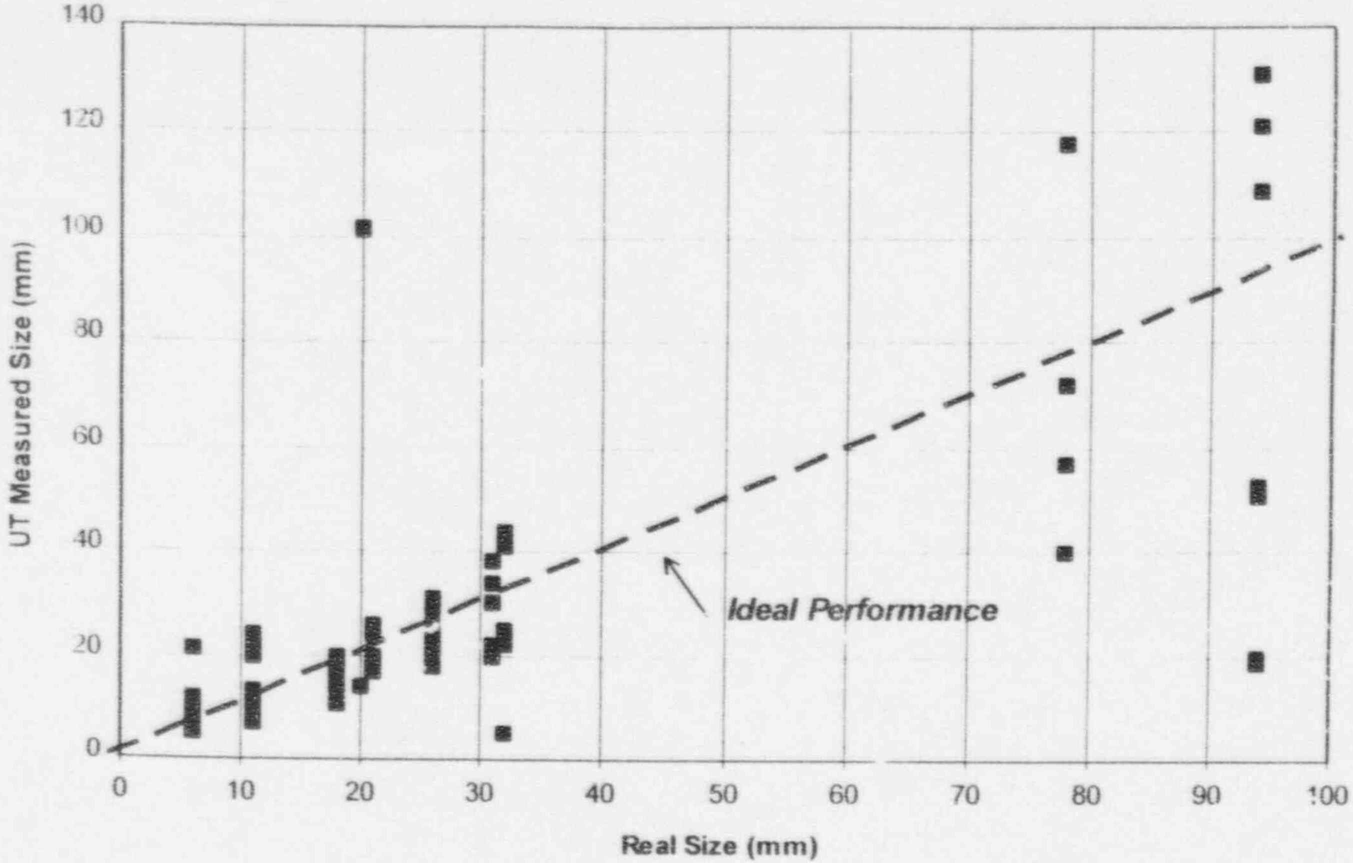

PISC II Plate 3 performance for defect detection probability (DDP) versus flaw depth for procedures working at a sensitivity of 50% DAC




PISC II Plate 3 performance for defect detection probability versus flaw depth for procedures working at a sensitivity of 20% and 10% DAC




PISC II Plate 3 performance for def ct detection probability versus flaw depth for special procedures




PISC III Action 2 on Full Scale Vessel of teams using special procedures for UT flaw sizing

# PERFORMANCE DEMONSTRATION

- Results of these studies showed that the ASME Code prescriptive UT procedures were not providing adequate reliability.
- A novel approach was needed to address improved inspection reliability.
- Performance demonstration would provide the solution to achieving improvement in NDE reliability.
- PNNL and NRC staff began working in 1981 to develop the basis for NDE system qualification criteria for the NRC to use in the preparation of a regulatory guide. Several documents were developed.
- Two industry meetings were held in 1983 and 1984 to discuss concepts, discuss the documents developed, and obtain input on NDE qualification criteria.
- Consensus from the second public meeting in 1984 was that ASME Code should develop requirements using the PNNL/NRC document as the basis.

## PERFORMANCE DEMONSTRATION (Cont.)

- During the next 5 years, over 100 participants were involved in the evolution of these requirements.

- Key Concepts of ASME Section XI Code Appendices VII and VIII

  - Prerequisite training and qualification
  - Statistically based performance demonstration tests
  - Personnel/equipment/procedures as a whole are tested and this combination is what passes/fails.

- Culminated in a major change in Code philosophy from prescriptive procedures to requiring that teams demonstrate acceptable capability before being permitted to perform field inspections.

# PERFORMANCE DEMONSTRATION (Cont.)

Performance Demonstration Detection Test:

- Blind Test
- Statistically based
- Screening test
- Designed such that the probability of passing the test are as follows:

*Piping*

- 50% POD and 20% FCP less than a 1% probability of passing.
- 90% POD and 20% FCP greater than an 85% probability of passing.

*Reactor Pressure Vessel*

- 70% POD and 20% FCP less than a 1% probability of passing.
- 95% POD and 20% FCP greater than an 85% probability of passing.

- Test does not quantify POD for any flaw size.

# PERFORMANCE DEMONSTRATION (Cont.)

Performance Demonstration Crack Sizing Test:

- Test Criteria based on engineering judgement of:
  - Round robin trials
  - IGSCC sizing testing in progress at EPRI NDE Center
- Passing Criteria for Piping
  - Length sizing within ± 1"
  - Depth sizing ≤ 0.125" RMSE
- Passing Criteria for RPV
  - Length sizing ≤ 0.75" RMSE
  - Depth sizing
    -- Slope not less than 0.7
    -- Mean deviation less than 0.25"
    -- Correlation coefficient not less than 0.70

# PERFORMANCE DEMONSTRATION (Cont.)

<u>Supplements for Performance Demonstration Contain:</u>

- Size of specimens
- Minimum number of specimens
- Fabrication conditions
  - crown size
  - geometric conditions
- Defect conditions
  - types of flaws
  - location and orientation of flaws
- Detection specimens
  - number of flawed and unflawed grading units
- Sizing specimens
  - number and sizes of flaws
- Acceptance criteria
  - detection test, and sizing test

# TABLE VIII-S2-1 FROM ASME SEC XI APPENDIX VIII

## PERFORMANCE DEMONSTRATION DETECTION TEST ACCEPTANCE CRITERIA FOR WROUGHT AUSTENITIC PIPING

| Detection Test Acceptance Criteria | | False Call Test Acceptance Criteria | |
|---|---|---|---|
| No. of Flawed Grading Units | Minimum Detection Criteria | No. of Unflawed Grading Units | Maximum Number of False Calls |
| 5 | 5 | 10 | 0 |
| 6 | 6 | 12 | 1 |
| 7 | 6 | 14 | 1 |
| 8 | 7 | 16 | 2 |
| 9 | 7 | 18 | 2 |
| 10 | 8 | 20 | 3 |
| 11 | 9 | 22 | 3 |
| 12 | 9 | 24 | 3 |
| 13 | 10 | 26 | 4 |
| 14 | 10 | 28 | 5 |
| 15 | 11 | 30 | 5 |
| 16 | 12 | 32 | 6 |
| 17 | 12 | 34 | 6 |
| 18 | 13 | 36 | 7 |
| 19 | 13 | 38 | 7 |
| 20 | 14 | 40 | 8 |

# Performance Demonstration History

| YEAR | ACTION |
|---|---|
| 1977 | NRC funds NDE reliability program at Pacific Northwest National Laboratory (PNNL). |
| 1981 | NRC Research Information Letter (RIL) #113 (based on PNNL research results) made a number of recommendations including performance demonstration (PD) for austenitic and dissimilar metal welds. |
| 1982 | Recommendations from RIL #113 were incorporated into ASME Code Case N-335. |
| 1982 | NRC program at PNNL began addressing issues of PD criteria |
| 1982-83 | IE Bulletins 82-03 (see Reference 3) and 83-02 (see Reference 4) mandated Intergranular Stress Corrosion Cracking (IGSCC) detection qualifications on cracked piping. Testing started at Battelle Columbus and then moved to EPRI NDE Center (NDEC) . |
| 1983 | – Code Case N-375, "Rules for Ultrasonic Examination of Bolts and Studs."<br>– IGSCC sizing qualifications at NDEC. |
| 1983 | NRC/PNNL workshop in Seattle, Washington, on Draft #1, "Qualification of UT for Nuclear ISI Applications" to discuss and obtain input on methods, criteria and various aspects of PD. |
| 1984 | Triparty agreement between NRC/EPRI/BWROG on IGSCC certification. |
| 1984 | NRC Technical Review Group meeting to achieve consensus and finalize draft regulatory guide on PD criteria in preparation for public meeting. |
| 1984 | – NRC public (international) meeting in Rockville, Maryland on the draft PD regulatory guide to obtain input and comment. ASME representatives recommended that the ASME should developed PD requirements based on the draft regulatory guide.<br>– Section XI authorized three task groups (personnel, PD, and implementation) to develop the necessary qualification requirements and criteria. |
| 1988 | – ASME Code Case N-409-2, "Piping UT Performance Demonstration."<br>– ASME Appendix VII, "Qualification of NDE Personnel for Ultrasonic Examination," in Winter 1988 Addenda. |
| 1989 | ASME Appendix VIII, "Performance Demonstration for Ultrasonic Examination Systems," in 1989 Addenda. |
| 1993 | 1993 Addenda adds Supplements 10 and 11 to Appendix VIII covering dissimilar metal welds and clad overlay repairs. |
| 1994-96 | Code changes and Cases on Appendix VIII based on 'lessons learned' from Performance Demonstration Initiative (PDI) Steering Committee activity. |

## SUMMARY AND CONCLUSIONS

- Research results, round robin tests, and experience since the 1970s have shown the poor reliability of many prescriptive inservice inspection techniques.
- Even as improvements have been made to techniques and procedures, there still is a large variability in the performance of NDE systems for similar procedures and equipment used by different inspectors.
- There is a need to qualify NDE systems, through performance demonstrations, to screen poor performers from the qualified pool of NDE systems that are used for inservice inspections.
- The acceptability of missing deep flaws in a passing detection test should be addressed.
- The inclusion of a criterion to the sizing qualification test for the maximum acceptable undersizing of deep flaws, in addition to the RMSE requirement, should be considered.

## REPORTS FROM THE NDE RELIABILITY PROGRAM (B-2289) AT PNNL


Heasler, P. G., S. R. Doctor. 1996. *Piping Inspection Round Robin.* NUREG/CR-5068, PNNL-10475. Pacific Northwest National Laboratory, Richland, Washington.

Vo, T. V., B. W. Smith, F. A. Simonen, B. F. Gore. 1994. *Feasibility of Developing Risk,-Based Rankings of Pressure Boundary Systems for Inservice Inspection.* NUREG/CR-6151, PNNL-8912. Pacific Northwest Laboratory, Richland, Washington.

Vo, T. V., B. F. Gore, F. A. Simonen, S. R. Doctor. 1994. *A Pilot Application of Risk-Based Methods to Establish Inservice Inspection Priorities for Nuclear Components at Surry Unit I Nuclear Power Station.* NUREG-CR-6181, PNNL-9020, Pacific Northwest Laboratory, Richland, Washington.

Heasler, P. G., T. T. Taylor, S. R. Doctor. 1993. *Statistically Based Reevaluation of PISC-II Round Robin Test Data.*
NUREG/CR-5410, PNNL-8577. Pacific Northwest Laboratory, Richland, Washington.

Doctor, S. R., A. A. Diaz, J. R. Friley, M. S. Greenwood, P. G. Heasler, R. J. Kurtz, F. A. Simonen, J. C. Spanner, T. V. Vo. 1995. *Nondestructive Examination (NDE) Reliability for Inservice Inspection of Light Water Reactors.* NUREG/CR-4469, PNNL-571 1, Vol. 16. Pacific Northwest laboratory, Richland, Washington.

Doctor, S. R., A. A. Diaz, J. R. Friley, M. S. Good, M. S. Greenwood, P. G. Heasler, R. L. Hockey, R. J. Kurtz, F. A. Simonen, J. C. Spanner, T. T. Taylor, and T. V. Vo. 1993. *Nondestructive Examination (NDE) Reliability for Inservice Inspection of Light Water Reactors.* NUREG/CR-4469, PNNL-571 1, Vol. 15. Pacific Northwest Laboratory, Richland, Washington.

Doctor, S. R., A. A. Diaz, J. R. Friley, M. S. Good, M. S. Greenwood, P. G. Heasler, R. L. Hockey, R. J. Kurtz, F. A. Simonen, J. C. Spanner, T. T. Taylor, and T. V. Vo. 1992. *Nondestructive Examination (NDE) Reliability for Inservice Inspection of Light Water Reactors.* NUREG/CR-4469, PNNL-5711, Vol. 14. Pacific Northwest Laboratory, Richland, Washington.

Green, E. R., S. R. Doctor, R. L. Hockey, and A. A. Diaz. 1992. *Development of Equipment Parameter Tolerances for the Ultrasonic Inspection of Steel Components: Application to Components up to 3 Inches nick.* NUREG/CR-5817, Vol 1. Pacific Northwest Laboratory, Richland, Washington.

Doctor, S. R., M. S. Good, P. G. Heasler, R. L. Hockey, F. A. Simonen, J. C. Spanner, T. T. Taylor, and T. V. Vo. 1992. *Nondestructive Examination (NDE) Reliability for Inservice Inspection of Light Water Reactors.* NUREG/CR-4469, PNNL-5711, Vol. 13. Pacific Northwest Laboratory, Richland, Washington.

Doctor, S. R., M. S. Good, P. G. Heasler, R. L. Hockey, F. A. Simonen, J. C. Spanner, T. T. Taylor, and T. V. Vo. 1992. *Nondestructive Examination (NDE) Reliability for Inservice Inspection of Light Water Reactors.* NUREG/CR-4469, PNNL-5711, Vol. 12. Pacific Northwest Laboratory, Richland, Washington.

Doctor, S. R., M. S. Good, E. R. Green, P. G. Heasler, F. A. Simonen, J. C. Spanner, T. T. Taylor, and T. V. Vo. 1991. *Nondestructive Examination (NDE) Reliability for Inservice Inspection of Light Water Reactors.* NUREG/CR-4469, PNNL-5711, Vol. 11. Pacific Northwest Laboratory, Richland, Washington.

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# NRC STAFF PRESENTATION TO THE ACRS

SUBJECT: USE OF ULTRASONIC TESTING IN INSERVICE INSPECTION PROGRAMS

DATE: APRIL 16, 1997

PRESENTER: ROBERT HERMANN
SENIOR LEVEL ADVISOR
MATERIALS & CHEMICAL ENGINEERING BRANCH
DIVISION OF ENGINEERING
415-2768

SUBCOMMITTEE: MATERIALS AND METALLURGY

## BACKGROUND

- 1970's USNRC observed UT needed improvement to detect and size flaws

  - BWR Pipe Cracks

  - BWR Feedwater Nozzle Thermal Fatigue Cracks

  - Reactor Vessel Examinations

## BACKGROUND, CONT'D

- Regulatory Actions

  - NUREG-0313 and revisions recommended formal program for UT examiner performance demonstration

  - IGSCC Coordination Plan, NRC, BWROG, EPRI

  - NUREG-0619 Recognized improved UT in lieu of surface exams

  - RG 1.159, Rev.1, " UT of Rx Vessels Welds for PSI and ISI" into TSs

## REGULATORY REQUIREMENTS FOR CODES AND STANDARDS

- 10 CFR 50.55a references ASME Boiler and Pressure Vessel Code, Section XI 1989 Edition (no Addenda)

- Currently, UT examination methods are required to meet minimum inspection standards (amplitude-based)

- Appendix VIII was incorporated into the 1989 Addenda to ASME Section XI*

- Current rulemaking will reference ASME Section XI up to and including the 1995 Edition

- Final rulemaking (expected in July 1998) will make Appendix VIII a requirement for all licensees

* Performance Demonstration Initiative (PDI) was established to manage implementation of Appendix VIII criteria

## WHAT IS APPENDIX VIII?

- Mandatory appendix in ASME Boiler and Pressure Vessel Code, Section XI (1989 Addenda)

- Performance demonstration method to qualify ultrasonic examination systems (equipment, procedures, and personnel)

- Tests ability of equipment, procedure, and personnel to detect and size flaws

  Pass-fail rate using Appendix VIII:

  22% failed to qualify for flaw detection
  41% failed to qualify for length sizing
  67% failed to qualify for depth measurement
  49% failed to qualify for IGSCC detection

- Highly effective method to qualify UT systems

## WHY DO WE NEED APPENDIX VIII?

- Existing requirements might not be adequate to ensure flaws can be reliably detected and sized

  Browns Ferry Unit 3 RPV Shell Examination

  - 15 flaws required analytical evaluation using Appendix VIII
  - 2 flaws required analytical evaluation using current Section XI

- Improves ability of examiner's disposition to indications

  Millstone Unit 1 IGSCC detection in piping

  - 35 cracks identified
  - 14 cracks previously identified as geometry or non-metallurgical

## WHY DO WE NEED A GENERIC LETTER?

- To emphasize the importance of Appendix VIII
- Industry and NRC recognize need for Appendix VIII
- Appendix VIII is not expected to become a requirement until July 1998
- GL will show NRC support for Appendix VIII now
- To indicate NRC support for PDI initiative
- GL will encourage licensees to use Appendix VIII for upcoming augmented vessel examinations

## PURPOSE OF GENERIC LETTER

- Notify licensees of UT enhancements and deficiencies in current UT qualifications

- Determine how the industry plans to ensure that flaws in the reactor vessel and piping are reliably detected and sized

- Determine extent to which licensees are using or plan to use performance demonstration to qualify UT (Appendix VIII to ASME Section XI)

## REGULATORY BASIS FOR GENERIC LETTER

- 10 CFR 50.55a Requires Conformance with ASME III and XI
- 10 CFR 50.55a(g)(ii) Commission may require augmented inspections if needed for added assurance of structural integrity
- 10 CFR 50, Appendix A, GDC 14 requires RCPB be … tested to have extremely low probability of leakage, rapidly propagating failure and gross rupture
- 10 CFR 50, Appendix B, Criterion XVI requires that measures be established to assure conditions adverse to quality are promptly identified and corrected
- 10 CFR 50, Appendix B, Criterion II requires QA program take into account … the need for verification of quality by inspection and test. Also program provide for indoctrination and training of personnel … to assure suitable proficiency is achieved and maintained

## CONCLUSIONS

- Experience such as PISC, BWR pipe inspections, PDI and Appendix VIII vessel exams indicate that current inspection requirements may not ensure flaws are reliably detected and sized
- Significant improvement can be made in volumetric NDE reliability if performance demonstration of procedures, equipment and personnel is utilized
- GL will establish the extent to which Appendix VIII is or is planned to be used for reactor vessel and piping inspections
- GL will encourage licensees to use Appendix VIII for reactor vessel and piping examinations
- GL will demonstrate NRC's support for Appendix VIII until rulemaking is complete